Chapter 3

PTOLEMY'S «ALMAGEST» AND ANCIENT SCIENTIFIC LITERATURE

Contents

In this chapter, we will analyze "for forgery" the largest scientific work of antiquity, Ptolemy's famous "Almagest", and will briefly discuss the general question of the medieval origin of ancient scientific literature as well as the question of the consequences of its apocryphing to antiquity.

Analysis of Ptolemy's work is based on rather subtle astronomical facts and requires the reader to be adequately prepared. We've made sure to set out all necessary information in advance in §1. Nevertheless, for an unprepared reader, this analysis may still seem somewhat complex.

§ 1. Coordinates of stars on the celestial sphere

Constellations

For an approximate indication of the location of stars (or any other objects) on the celestial sphere, we use *constellations*, i.e. some conventional, historically defined groupings of stars. Particularly important are constellations located on the path of the visible annual motion of the Sun. These constellations are *zodiacal*, and the strip of sky they occupy is the *zodiac.* There are 12 zodiacal constellations total, and in each of them, the Sun is approximately for about a month.

The origin of the names of zodiacal constellations fades in the darkness of time. In any case, there is no doubt that their origin can be traced back to the birth of astronomy (in the form of astrology).

Besides the name, each zodiacal constellation also has its own symbol, also with astrological origin. The meaning of each such symbol (as far as it can be deciphered) is usually the same as the constellation's name.

Zodiacal constellation	Sign	Which month the sun is in the constellation	
Pisces	♓	**March**	**spring**
Aries	♈	**April**	
Taurus	♉	**May**	
Gemini	♊	**June**	**summer**
Cancer	♋	**July**	
Leo	♌	**August**	
Virgo	♍	**September**	**fall**
Libra	♎	**October**	
Scorpio	♏	**November**	
Sagittarius	♐	**December**	**winter**
Capricorn	♑	**January**	
Aquarius	♒	**February**	

However, at any time of the year, the constellations hosting the Sun are actually inaccessible for observation,

and, on the contrary, the opposite part of the zodiac is easier to observe.

The Sun's movement through the zodiacal constellations changes gradually with time (see below). For example, in the present day, the Sun passes the middle of the constellation Aries around April 17 (old style), but in the beginning of our era, it passed the middle of this constellation on April 4. For such cases, there is a detailed table of positions of the Sun in constellations from our time and up to the year 3000, compiled by Viliev. It is reproduced in [4] (p. 51).

The stars of the constellations are designated with Greek letters (alpha, beta, gamma...), usually in descending order of brightness. This method was proposed by Bayer in 1603 and has since come into general use.

The location of objects on the celestial sphere can be given more precisely using two coordinates. There are many different coordinate systems. We will describe the four most important.

General Terms

Perpendicular to the ground at the point of observation is the **plumb line**. The major circle, perpendicular to the plumb line, is the **horizon**.

The plumb line crosses the celestial sphere up at the **zenith** and down at the **nadir**.

Any major circle passing through both the zenith and the nadir is the **circle of altitude** or the *vertical circle.* One of these circles, passing through an object, is the object's **vertical**.

A line passing through the center of the celestial sphere parallel to the Earth's axis of rotation is the **world axis**. Its points of intersection with the celestial sphere are *the poles of the world.* The pole for which the daily rotation is clockwise (as observed from the center of the celestial sphere) is the **South Pole**, and the opposite one is the **North Pole**.

Near the North Pole, one can see *the Polaris* (Ursa Minor alpha), a star of quite a significant brilliance.

A point on the horizon, closest to the North of the world is the **North Point**, and the opposite one is the **South Point**. Between the North and South points are the **East Point** and the **West Point**.

Horizontal coordinates

In the hemisphere with the South point, the **azimuth** of an object is the arc on the horizon, starting at the South Point and going west to the object's vertical.

The **altitude** is the arc starting at the horizon and going to the zenith or nadir until it hits the object.

Sometimes, instead of altitude, the opposite value called *the zenith distance* can be indicated. The zenith distance is the arc on the vertical from the zenith to the object.

Azimuth and altitude (or zenith distance) completely determine the position on the celestial sphere. These are the **Horizontal Coordinates**. Due to the rotation of the celestial sphere, they drift continuously.

Equatorial 1

Any major circle passing through both poles of the world is the **declination circle** or *the hour circle.* The declination circle going through the zenith is the *celestial meridian.* The circle on the celestial sphere that is imagined perpendicular to the world axis is the *celestial equator.* The celestial equator divides the celestial sphere into the northern and southern hemispheres. The celestial equator is misaligned with the Earth's equator and only intersects it at the points of East and West.

The hour angle is the angle on the sphere from the highest point on the celestial equator (i.e. from the observer's meridian) to the object's declination circle. The hour angle is the arc on the equator starting from its

southernmost point and going west to the object's declination circle. Often, instead of degrees, an *hour* is used, by definition equal to 15° (as 1/24th of a full circle). The hour angle changes proportionally to time (hence counted in hours).

The declination is the arc on the object's declination circle starting at the equator and going north or south to the object. Declination does not depend on the rotation of the celestial sphere.

Instead of declination, the **polar distance** of the object can be defined as the arc on the declination circle going from the North Pole to the object.

Hour angle and declination also clearly determine the position of an object. This is the **Equatorial 1.**

Equatorial 2

The *ecliptic* is the circle on which the Sun makes its visible annual path. The ecliptic plane is parallel to the plane of the Earth's orbit. The angle of inclination of the ecliptic plane of the sky to the equatorial plane of the Earth changes slowly over time. It is currently approximately 23°27' (about 23.5°).

The two opposite points of the celestial sphere that are farthest from the ecliptic, are the *poles of the ecliptic*. The North Pole of the ecliptic is currently located in the constellation of the Dragon, midway between Polaris and Vega (Lyra alpha), one of the brightest stars of the Northern sky. The South Pole is located in the constellation of the Goldfish. Every circle, which goes through both poles of the ecliptic at the same time is the **circle of latitude**.

As the Sun moves from the Southern to the Northern hemisphere, it passes the point of intersection of the celestial ecliptic and the celestial equator, which is the **point**

of spring or the *point of the vernal equinox* (because at this point the durations of day and night are equal), denoted with letter U. The opposite point is the **point of fall** or the *point of the autumnal equinox*, denoted with letter D. The spring point is in the constellation Pisces and the fall point is in the constellation Virgo. There aren't any bright stars near these points.

The circle of declination going through the spring point and the fall point is the *colure of the equinoxes.*

In the northern hemisphere, the moment of the Sun passing through the point of spring (or autumn) is considered the astronomical beginning of spring (or autumn). According to the current Gregorian calendar, spring begins on March 21 (the day of the vernal equinox), and autumn - on September 23 (the day of the autumnal equinox).

Direct ascension is the arc on the celestial equator starting at the point of spring and going east (i.e. horizontally, so direct ascension is deceptively named horizontal "ascension" - tr.) to the object's declination circle. Direct ascension, like declination, is independent of the daily rotation of the celestial sphere. **Direct ascension** and **declination** make up **Equatorial 2.**

In astronomical tables, the location of an object is usually defined just by declination and direct ascension.

The difference between the hour angle and the direct ascension (i.e. the difference between the southernmost point and the spring point – tr.) is equal to the hour angle of the spring point. This hour angle is *star time* (sidereal time). Therefore, at the given time, star time is the same for all objects.

Ecliptical coordinate system

Longitude is the arc on the ecliptic, it starts from the spring point and increases its direct ascension until it hits the object's circle of latitude. Longitude is counted from 0 to 360°.

Latitude is the arc on the circle of latitude, starting at the ecliptic and going north or south to the object. Latitude is counted from 0 to 90° or to -90°.

Longitude and **latitude** make up **Ecliptical CS.**

This concludes our observation of coordinate systems.

24-hour movement

We all know the picture of the daily motion of objects well. Every object moves uniformly, counterclockwise for an observer in the northern hemisphere of the Earth, in a circle that is parallel to the equator.

If a star's **polar distance** ρ is less than the place of observation's northern **geographic latitude** φ, the entire said circle lies above the horizon. This is *a non-setting star*.

If $\rho>\varphi$ and $\rho+\varphi>180°$, the star never appears above the horizon. This is *a non-rising star*.

If $\rho<180°$ and $\varphi<180°$, the star *rises* and *sets*. The rising (setting) of a star coinciding with the rising (setting) of the Sun is *called heliacal.*

In 24-hour rotation, the passage of an object through an observer's meridian (when he sees that the object passes its highest point – tr.) is the object's culmination. Culmination south of the North Pole of the world is called *upper culmination*; otherwise, it is called *lower culmination.*

Star day (sidereal day) is 24 hours of star time (tr.: in English, there is no singular word for a 24-hour day), i.e. the time between two consecutive upper culminations of a certain star (we neglect the stars' own movements here).

The *star year* (sidereal year) is the time of the Sun's return to a certain star during the Sun's annual motion (the period of the Earth's orbital cycle). The *star year* is shorter than the tropical year by 20 minutes.

Determination of objects' coordinates from observation

The **polar distance** of a non-setting star is equal to a half-difference of its zenith distances at the culminations. Therefore, observing culminations allows one to determine the declination of non-setting stars.

For any star, the sum of its declination, zenith distance at the lower culmination, and geographic latitude of the observer equals 180°. Therefore, observation of non-setting (better be near-polar) stars makes it possible to determine the observer's latitude. When one knows his own latitude, he can calculate any star's declination by measuring its zenith distance at any culmination. Thus, *to determine the declination of a star,*

just measure its zenith distance at the culmination, which is easily accomplished with the simplest angular measurement instruments fixed in the meridian plane (unless great accuracy is required, of course).

If direct ascensions are counted not from the spring point, but from a certain bright star (just like it was at the dawn of astronomy), then, *to determine the direct ascension of an object, you just need a clock*: the direct ascension is equal to a time between culminations of the object and the «initial» star.

However, if you count the direct ascension from the point of spring, not marked on the celestial sphere with any bright star, you have to act in a rather complicated way to determine it:

For example, we can measure the meridional zenith distances of the Sun to find its declination. It changes continuously, reaching its maximum at the solstices. But since this maximum is the same as the ecliptic's inclination

to the equator, thus we will find this inclination as well. Now, knowing the ecliptic's inclination as well as the Sun's declination, we can solve the corresponding spherical triangle and find the Sun's direct ascent. Then we just take the Sun as the «initial» star.

But since the Sun's observations are technically difficult and insufficiently accurate, the point of spring is determined from observations of other bodies of the Solar System; in particular, from observations of the minor planets.

In any case, we can see that to measure either of the equatorial coordinates (declination or direct ascension), we still need to observe stars at their culminations. All we need is a sufficiently precise **angular instrument** to measure zenith distances and a **precise clock** to mark the moment of culmination.

Zenith distance is harmed by refraction (rays slightly changing direction in the Earth's atmosphere). Refraction error can reach 0.5°.

Instead of going for the equatorial coordinates directly, sometimes it is more convenient to use instruments like theodolite or astrolabe to obtain the horizontal coordinates (i.e., azimuth, unaffected by refraction) directly from observations, and then, knowing the exact time of observation and using the formulas of spherical trigonometry, recalculate the azimuth into declination and direct ascent.

Nowadays, ecliptic coordinates are not found from observations, but calculated from equatorial coordinates. However, previously they, too, were found from observations: for example, the so-called *armillary spheres* belonging to Tycho Brahe have been preserved, with which he was calculating the longitudes and latitudes directly. However, this method produces much worse results in terms of accuracy.

Ecliptic coordinates are useful for studying the motion of planets, but for objects like stars, without their own motion around the Sun, ecliptic coordinates are

inconvenient (both from a theoretical and practical, observational point of view). That is exactly why all modern astronomical tables use equatorial coordinates.

Precession

However, equatorial coordinates have one essential, though, not so practical, but theoretical defect: they slowly, but rather noticeably, change over time. This change is caused by the *precession* of the Earth's axis; the precession consists in the fact that the axis does not remain stationary, but moves along a certain cone (This is the well-known motion of a spinner). The precession of the axis is very slow: one revolution takes about 26’000 years. Precession does not change the tilt of the Earth's axis to the orbital plane. Therefore, as a result of precession, in 26’000 years the pole of the world makes a circle centered at the pole of the ecliptic, having a radius of approximately 23.5°. As we have already noted, in the present day the pole of the world is near Ursa Minor Alpha (Polaris), but 4000 years ago the

closest star to the pole was Dragon Alpha, and 12'000 years from now Vega (Lyra Alpha) will become the new Polaris.

Since the pole of the world precesses, the terrestrial equatorial plane also precesses with it (relative to the celestial ecliptic plane), which is expressed in the crawl of the equinox points west. For example, since the beginning of our era, the point of the vernal equinox has moved from the constellation of Aries to the constellation of Pisces. The magnitude of this drift is full 360° in 26'000 years, and hence the equinoxes move about 50.2" in a year (1.393° in a century). This magnitude is *the total annual precession.*

(tr. - a fraction of a degree is an angular minute,
designated with a single apostrophe: 1'
angular second is designated with two apostrophes: 1")

In the equatorial coordinate system, the origin is the point of the vernal equinox. Due to its motion, declinations and the direct ascensions move as well. This causes a very slow change in the appearance of the starry sky. Thus, in a few thousand years, Orion and Sirius will set downward, and

the Southern Cross, currently not visible in Europe, will appear.

Since the motion of the equinox points is facing against the annual motion of the Sun, the Sun enters these points earlier and earlier every year. This causes the *precession of the equinoxes*, i.e. their earlier onset. And that's why the tropical year is 20 minutes shorter than the star year - this is exactly how long it takes for the Sun, moving East by 1° every day, to travel an extra 50.2". This drift of the tropical year relative to the star year is also called precession.

Precession of calendar

To measure major periods of time in everyday life, we use some sort of a calendar. The corresponding calendar year inevitably diverges from the tropical year. This divergence combined with the difference between the tropical and the star years - i.e. **this difference between the calendar and the star year** is the *precession of the calendar*. It can be measured either in degrees or in days.

The precession of the modern Gregorian calendar, as the closest to the theoretical ideal climatic calendar, closely follows the precession of the tropical year and equals 1.396° per century. The precession of the Julian calendar was equal to 0.627° per century (so the Julian year surpasses the Gregorian year in their attempts to mimic the star year), and the precession of the Jewish calendar equals 0.99°, i.e. almost 1° per century.

Precession of ecliptic

The precessional drift of the spring point also causes a shift of ecliptic coordinates. Obviously, all stars' longitudes increase annually by 50.2" as a result of precession. This shift of longitudes can be eliminated by taking a star, instead of the spring point, as the origin. For example, this is what Copernicus did when he took the Aries Gamma as the starting star. Thus, Copernicus was expecting to obtain a «perpetual» star catalog, since, as one can see easily, the latitudes of the stars are not affected by precession. However, it was later discovered (and was long suspected by Tycho Brahe, but finally established later in the 18th century) that, in fact, the ecliptic plane is also subject to precessional drift. This drift is very small and unstable. At present, it is approximately 0.11″ per year (tr. – i.e. 500 times slower than the drift of longitudes).

§ 2. Ptolemy and «The Great Creation»

Characteristic of Ptolemy

Along with Hipparchus, Ptolemy is considered the founder of modern astronomical science, and Ptolemy's work «Almagest» (*«The Great Creation»*) is considered the immortal monument of ancient science. For example, here is what Idelson, the famous Soviet historian of astronomy, writes, stating the traditional point of view:

«Claudius Ptolemy was an astronomer of the 2nd century AD. From his book, the full title of which is «*The Mathematical Syntax (i.e. Treatise) on Astronomy in 13 Books*», it appears that he was observing in Alexandria, in Egypt, in the middle of the reign of Antoninus Pius (138-161 AD). *There isn't any other biographical information available about him,* but in the Middle Ages, the very consonance of his name with the names of numerous dynasts that ruled Egypt after the death of Alexander the Great (Ptolemy Lag,

Ptolemy Soter, etc.) was giving his Syntax a kind of a mysterious halo. (Isn't it why, unlike so many other things, this vast treatise came down to us in impeccable preservation?).

In Latin countries Syntax was initially learned through the Arabic translations of the Greek text; the translations belonged to the 9^{th}-11th centuries; the Arabs also established the very title of «The Almagest» for the Ptolemy's treatise, a corruption of the Greek word «Megiste», i.e. «the greatest». The first printed Latin edition of The Almagest was released in Venice in 1515. It was a heavy translation from the Arabic manuscripts performed by Gerard of Cremona back at the end of the 12th century. The next Latin edition (Venice, 1528) was based on the first and poor translation produced directly from the Greek codices (manuscripts) by George of Trebizond in 1451. The first printed publication (editio princeps) of the Greek text was released in Basil in 1538, just five years before Copernicus' book «On the Revolutions of the Heavenly Spheres» appeared. Besides "The Almagest", Ptolemy is credited with

«Geography», the astrological treatise of «Tetrabiblos», and other studies.

Hipparchus, «the father of astronomy» originating from the town of Nicaea at Bethany, Turkey, observed between 160 and 126 BC, i.e. about 300 years before Ptolemy, partly on the island of Rhodes, partly in Alexandria, and nothing else is known about him.

In «The Almagest» Ptolemy uses numerous observations and results, really amazing in depth and accuracy, given by Hipparchus for the theories of the Sun and the Moon, as well as materials Hipparchus prepared for the coming theory of the planets (creation of the latter undoubtedly belongs to Ptolemy himself). Unfortunately, all those works of Hipparchus mentioned by Ptolemy haven't been preserved, and so the name of Hipparchus is associated only with an unimportant «Commentary» on the poem about heavenly phenomena, composed by certain Aratus (2nd century BC)» ([84], pp. 471-472).

It is undeniable that the name of Ptolemy (meaning, as Morozov points out, «contending with God») was already known in the pre-printing era. For example, in the 13th century, Ptolemy was spoken of with great respect by Albert the Great, the teacher of Thomas Aquinas. However, careful study of mentions of Ptolemy's name and loose retellings of certain fragments of his study in the compositions of medieval authors shows that **nobody of them,** as it was repeatedly and with displeasure noted in the history of science, **ever held in his hands** the very «Almagest» we know. (The aforementioned Albert the Great characterized Ptolemy only as an outstanding astrologer and magician).

Editions of Almagest

Gerard's translation was allegedly made in 1230 at the order of Frederick II (1194-1250), from an Arabic translation made as if in 827 (and according to Montignot – even later in the 11th century) from the Greek manuscript of «Almagest». On this translation, Bodet in his book on «The

Almagest» says the following: «From the comparison of the Latin text with the Arabic it was noted that the text (which one? - tr.) is incorrect» (see [4], p. 194). About the translation by George of Trebizond, published in 1528, we do not have any information.

Thus we shall focus our attention on the Latin edition of "The Almagest" released in 1537 in Cologne (Köln – tr.). This translation (which Idelson doesn't mention for some reason) also (!) belongs to the feather of George of Trebizond, and its title page states clearly that this is **the first publication of The Almagest.**

Here is this title page:

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from Claudius Ptolemy

Theludian Philosopher of Alexandria and the Most Excellent Mathematician

Heavenly phenomena of 1022 static stars

brought to the current time, especially for students

Now published for the first time

by the translator George of Trebizond

With an appendix with John Noviomag's introduction to longitudes and latitudes of the static stars, and also with an appendix with 48 images of the Moorish sphere

By Albert Dürer

Published in Cologne, 1537, August 25.

Basil edition of 1538 was produced from the Greek manuscript that is currently stored in the Library of Nuremberg. Following this Greek edition, the 2nd edition of the Latin translation was released in Basil in 1541, repeated from the 1537 edition (Bodet, however, thinks, that, on the contrary, it is the 1541 edition that is a reprint of the Venetian edition), and in 1551 there was the third edition.

The abundance of these editions shows that in the 16th century, the information contained in Ptolemy's book was not considered outdated, and, despite 14 centuries of age, for the scientists of that time it possessed **living and trembling interest of the latest scientific progress**. This idea was expressed in different words by Neugebauer, one of the greatest specialists in the history of the exact sciences, when he pointed out that «there isn't any better way to be convinced about the internal agreement of the Ancient and the Medieval astronomy than to put side by side «The Almagest» by Ptolemy, «The Opus Astronomicum» by al-Battani, and «De Revolutionibus» by

Copernicus. Chapter by chapter, theorem by theorem, table by table - *these works run parallel»* ([23] p. 197). Neugebauer also states that «one can't read a single chapter of Copernicus or Kepler without a thorough knowledge of Ptolemy's Almagest» ([23] p. 19).

Star Catalog

One of the most important parts of "The Almagest" appears to be the **star catalog**, on which the text says that it was compiled in the 2nd century (during the emperor Antoninus Pius, to be precise) after the author's **personal observations** and using data of Hipparchus.

The first thing that draws attention is the **surprising preservation** of this catalog, unaffected by all the rewrites that would be inevitable for preserving it in the course of over a thousand years. After all, every editor-publisher knows how many mistakes even the most attentive person makes in rewriting digital material. This alone makes us doubt unapocryphality of "The Almagest".

The second feature of the catalog appears to be its **exceptional accuracy** - the coordinates of stars are given here with accuracy down to 1/6 of a degree. Of course, with the scrupulous craftsmanship of an instrument, it would probably be possible to achieve such precision of angle measurement even with antique technology. However, we also know, that, to measure the coordinates of celestial bodies, angular instruments alone are insufficient - one also needs an accurate clock (to acquire from observations star coordinates with accuracy specified by Ptolemy, one needs at least a minute-counting clock). Ptolemy describes used instruments in detail, armillary sphere for example, but says nothing about clocks. This can only be explained in a way that methods of counting time widely accepted back in the day satisfied him quite well, providing the required accuracy. However, this strikingly contradicts any traditional information about clock technology of that time (see, for example, [96]). Historians of astronomy noticed all this long ago but being under the hypnosis of the authenticity of Ptolemy's text, they could only shrug in bewilderment.

Pay attention that the clock with a minute hand appeared in Western Europe as late as in the 15th century, and **at the same time** began the blooming of the «uranometry» – that's what the art of determining star coordinates was called in those days.

The third alerting feature of Ptolemy's catalog is that, like modern astronomers, **it counts longitudes from the point of the vernal equinox**, and we do know what kind of difficulties are associated with determining this point's coordinates (see §1), practically impossible without a clock counting fractions of minute.

But all these considerations, causing skeptical attitude to the star catalog of «Almagest», can be challenged: after all, it could be possible that a pleiad of exceptionally attentive scribes appeared miraculously and Ptolemy with Hipparchus possessed some methods of counting the time that we could never guess about. We could develop our ideas on this matter in greater detail and, hopefully, with greater conviction, but actually, there is no need to do so

because there is a reliable method how to restore the moment of the catalog's compilation from the catalog itself.

Moment of Catalog's Compilation

Indeed, since the catalog indicates the ecliptic coordinates of stars (longitudes and latitudes), and longitudes, as we know, increase by 50.2″ (angular seconds) every year as a result of precession, then, upon finding the difference between the modern star longitudes and the Ptolemy's longitudes, and dividing this difference by 50.2″, we would immediately get the year of catalog's compilation. This elementary calculation gives a shocking result: turns out, **all longitudes of stars** indicated in the first Latin edition of «Almagest», **were observed in the 16th century AD**, i.e. belong to the time of this book's release!

How come this striking fact hasn't been noticed long ago by Bodet who carefully studied and commented on «The Almagest»? It turns out (see [4], p. 179), that Bodet studied **the second, Greek edition,** which *is* allegedly the

original (and Bodet's position is absolutely natural: why read Latin «translation» if Greek genuine «original» is there?), and in this second edition (released a year after the Latin one) the longitudes of all stars are reduced by 19°50″ compared to longitudes in the Latin edition, which gives positions of stars at the 2nd century AD.

This is irrefutable evidence in favor of the primary nature of Latin text and the secondary nature of Greek text. The unknown author of the 16th century (we've yet to talk about his identity), who has published an alleged «translation» of the Greek original first, didn't care to eliminate the influence of precession, and when it was pointed out to him by his good friends, he urgently made the necessary corrections.

Precession value

But if the Greek text appears to be a falsification, there would be some traces left. And indeed, there are such traces, and moreover, there are quite a few of them.

In the 16th century, the most widespread was the idea that the annual precession value equals 51" in a year, i.e. 1.417° in a century. Then a simple division of the difference between the longitudes of the Greek edition and the Latin edition (longitudes of the 16th century) would give that the difference should accumulate over 1399 years, and thus the moment of the book's writing would fall on 139 AD, i.e. precisely the second year of Antoninus Pius's reign, just like it is indicated in the book. Having calculated the year of the book's «compilation» that way, its 16th century author wrote it in the text as the moment of his observations, thus hoping to conceal the genuine moment of observations and the moment of writing.

But the genuine value of precession is different! La Lande and, in his wake, Bodet (on the eve of the 19th century) utilized a more accurate value of precession to check once more the moment of observations described in «The Almagest». How did it turn out? Turns out, the catalog was compiled not during Antoninus the Pious, but during the impious Nero, in 63 A.D.!

This circumstance caused shock in specialist astronomers because it clearly indicated direct contradictions in the text of «Almagest». To find some way out of the situation, it was presumed that Ptolemy actually made use of observations of some astronomer who lived before him, without indicating the source of his information, although The Almagest states clearly that all observations are carried out by the author personally. Then, very incidentally, in the present day already, Wilhelm Gundel made an unexpected discovery: in a certain old French and another related Latin astrological manuscript of the Renaissance, he found inclusions of fragments of star catalog, and the said catalog was attributed, based on the calculation of precession, to the time of Hipparchus (i.e. around 150 BC). This laid the foundation for the theory that, since the Greeks were inclined to pure philosophical speculation and neglected observations and experiments, then «it can be considered proven»(!) that Ptolemy took Hipparchus' catalog, modified it trivially, systematically

increasing all longitudes of Hipparchus' stars by 2.40°, and wrote in the text that he observed all of it personally.

Naturally, such accusation of Ptolemy of fraud caused a negative reaction from the specialists. For example, Ball and Vogt began to prove that Ptolemy couldn't borrow data from Hipparchus' catalog. Gundel didn't pay attention to Vogt's work and still stood his ground. Neugebauer takes a neutral position on this matter, providing arguments pro as well as contra this assumption (see [23], pp. 80-81).

Could the 16th century author of "The Almagest" have thought that his inaccuracy would cause such a discussion 300 years later? Nowadays there is an entire sub-genre of literature devoted to «the problem of correct dating» of "The Almagest". But from Morozov's viewpoint, there isn't any problem here.

Objection. Precession in Ptolemy

However, one can offer an objection to the idea that the Greek edition could be corrected in comparison to the

Latin one, according to the 51″ precession value: the point is how the author of «Almagest» couldn't possibly know this value. Indeed, in Book 7, Ptolemy writes: «...Thus it was discovered that the stars move 1° in a century in the direction of the Zodiac signs», which gives a precession value of 36″ in a year.

Here we encounter another circumstance, which also caused a lot of trouble for specialists. The problem is that elsewhere (in Books 3 and 4) Ptolemy implicitly indicates correct (for the state of science in the 16th century!) precession value, reporting (incredibly accurate) Hipparchus' definitions for the duration of the tropical and the stellar year. According to Hipparchus, they differ by 19 minutes, which gives an annual precession of 46.8 seconds.

As we have already noted, every systematic calendar newly introduced in the ancientry should have been considered by its authors as climatic (ideal), because nobody would want to establish a calendar with a beforehand known error that would make indicated seasons unfit for

household life in a few decades or centuries. Therefore, the precession of stars must inevitably be identified with the precession of the calendar, and so the precession indicated by the ancient author allows one to find which calendar he used.

What do we see in Ptolemy? He uses the Julian calendar, but the 1° precession that he indicates is **the precession of the Jewish calendar,** by no means established no earlier than the 5th century AD (see [21], p. 145), and perhaps even in the 10th century (see [4], p. 152).

To cut this knot of contradictions, one has to conclude that **the 16th century author did not write the entire huge Almagest on his own**: he compiled it from various sources, merely adding the results of his own research, and one of those sources belonged to an author, who used the Jewish calendar.

Thus, the objection in question turns into another argument in favor of the late composition of "The Almagest".

Objection. A textbook for students

In the 16th century, Ptolemy's book was being published not as a document from the history of science, but as a scientific treatise for direct use by scientists and students. The Ptolemy's catalog's data, outdated because of precession, contradicted this purpose and so the translator of the Latin text «refreshed» the catalog, giving it the newest data of that time. But the publisher of the Greek text was approaching the matter differently: with the Latin translation available, the Greek text wasn't needed as a textbook anymore, and so the publisher restored Ptolemy's initial numbers.

This reasoning even seems to be supported by the title sheet of the Latin edition which states clearly: «for students especially brought to this time".

Thus, this objection acknowledges the apocryphal nature of the first, Latin edition (at least in regards to the star catalog), but denies the apocryphal nature of the later, Greek text.

Improvements in the Greek edition

This objection is refuted as in the 2nd, Greek edition, seemingly «original» coordinates of many (most remarkable) stars are actually improved significantly compared to the 1st, Latin edition. More accurate coordinates are indicated for the Capella, Sirius, Alpha Perseus, Vega, Deneb, Altair, Alpha Ophiucus, etc. The latitudes of Aldebaran, stars of the Dragon, Ursa Minor, etc., are improved significantly; the Greek edition of 1538 is literally teeming with improvements of such kind over the Latin edition of 1537.

A list of all (only discovered so far!) corrections in the Latin edition is given in [4] (p. 196).

Accounting for refraction

However, it doesn't end here. Comparison of the latitudes of stars in the Latin «translation» against the Greek «original» reveals that **all latitudes of the Greek edition are systematically increased** by 25' (minutes) compared to the latitudes of the Latin edition, or replaced with more

accurate ones. This systematic correction does not appear to be a correction for precession, because latitudes do not precess (they do, negligibly, see the end of §1 - tr.). Careful examination of this correction shows that it appears to be circular i.e. the entire ecliptic is moved to the South nearly by the diameter of the Sun. It is interesting how this correction improves the coordinates of stars located near the Zodiac but makes worse the coordinates of stars located closer to the pole of the ecliptic.

What's the matter? The answer: The author introduced systematic correction for refraction without taking into account that this correction, equal to the diameter of the Sun, decreases closer to the pole of the ecliptic. The author couldn't manage to calculate this modern differential correction and limited himself to the systematic shift of all the stars.

Thus, «restoring» Ptolemy's data in one respect, the publisher of the Greek text was improving (or trying to improve) it in another. Consequently, the Greek text is also apocryphal.

Skew of the ecliptic

There is another disadvantage with star latitudes in both editions of “The Almagest”. As it was noted by Bodet (see [4], p. 182), and also by Tycho Brahe even earlier, the latitudes of stars, given in «The Almagest» for constellations Capricorn and Gemini compared against modern latitudes show, that in «The Almagest» the ecliptic in Gemini is lowered to the South by about a half of a degree, but in Sagittarius and Capricorn raised to the North just as much. This would seem like yet another emphasis on the accuracy of Hipparchus' observations because this kind of skew of ecliptic does exist and is caused by its precession. However, Bodet pointed out reasonably that the deviation of the ecliptic in “Almagest” is almost 1.5 times greater than its theoretical value, and expressed his deep bewilderment, not understanding what could cause such a huge systematic difference.

Assuming that the author of «Almagest» already knew about the ages-long fluctuations of the ecliptic but his measurements gave him only a rough value, something like 2 arc minutes per century, he could make this correction, wishing to apocryphalize the ecliptic to the beginning of our era. But he miscalculated again because the genuine value of this drift is only *3/4* of a minute, and that's where the systematic difference noticed by Bodet comes from.

Of course, this assumption (beforehand implying compilation of «The Almagest» in the 16th century) is very unlikely because discovery as important as the precession of the ecliptic has no reason to conceal it but on the contrary, there is every reason to spread it as wide as possible. However, one can offer another, significantly more natural explanation associated with yet another oddity in the star catalog of "Almagest": it is about the author of the catalog using ecliptical coordinates rather than equatorial ones, which would be significantly more accurate and also easier to determine from observations.

Ecliptical Coordinates

Assuming that the author of «Almagest» initially determined the positions of stars in equatorial coordinates and only after that recalculated them into ecliptical ones, the skew of the ecliptic is explained immediately with rounding errors. It was enough for the author to put in his calculations the polar distance of the ecliptic pole equal 23° exactly instead of 23.5° to get a systematic difference that surprised Bodet.

But why wouldn't the author keep the initial equatorial coordinate system (as they do in all modern catalogs), but undertake this giant effort instead, to recalculate his coordinates into ecliptical ones? After all, he must have had to use cumbersome methods, introducing secondary errors. All this enormous work appears to be so grandiosely-useless, that one involuntarily wants to find some extraneous reason for it. Morozov points out that there could be only one such reason: a vain (but, let us note, fruitless) desire to make his catalog eternal, and thus hide apocrypha.

The beginning of the star catalog

A trace of the original equatorial coordinate system can be found even in the order in which the stars are cataloged. Just like modern astronomers, Ptolemy begins his catalog from the Polaris (Ursa Minor alpha), i.e. from the pole of the *equatorial* coordinate system. If the author would initially compile his catalog in the ecliptical system, it would be natural to start it from the pole of the ecliptic, located in the constellation of Dragon, and catalog stars of this constellation first. But in reality "The Almagest" firstly catalogs the stars of Ursa Minor, then the stars of Ursa Major, and only after that – the stars of Dragon. Moreover, beginning the catalog at Polaris, the author allows for another anachronism: Polaris appears to be the nearest to the pole of the world in the present day only; but in the 2nd century, the nearest to the pole was the opposite star of the same Ursa Minor - Beta. And even if in the 2nd century AD the author of «Almagest» could have in his head some strange fantasy to begin his catalog at the constellation of Ursa Minor, then, among two stars – Polaris and Beta – it

would be natural to choose Beta as the brighter one (Beta possess star size of 2, and Polaris – a mere 3). Thus the author reveals the actual moment of the catalog’s compilation again.

The end of the star catalog

Ptolemy's catalog ends in a way no less remarkable. After listing constellations of the Northern Hemisphere, Ptolemy moves on to those stars of the Southern Hemisphere which are visible in Europe. As the final one, he indicates the star Achernarus in Eridanus, which could not be observed in Alexandria in the 2nd century AD because it was 10° below the horizon, and one had to travel 600 km into Africa to see this star on the horizon. Later, by the 15th century, the star had already risen above the horizon due to precession and could be observed in Southern Europe. Nevertheless, its low position was making it difficult to observe, so it is only natural, that its coordinates in the 1st, Latin edition of 1537, are indicated incorrectly, with an error. In the 2nd, Greek edition, this error had been corrected

already, clearly according to more accurate dedicated measurements.

In general, one can notice that the boundary of the Southern constellations described in «The Almagest» better matches the horizon of Rome and central Italy rather than the horizon of Alexandria.

Star Charts

As indicated on the title page, this edition of The Almagest comes with 48 stellar maps engraved by Albrecht Dürer. As Morozov writes:

«Up until the beginning of book printing, astronomers were content to study the starry sky itself, in nature, without transferring it to drawings, and this was quite natural: what would a portrait serve for, if every clear night one could see and study the original? And so, only animal figures themselves as they were imagined in the sky, i.e. without any stars, were put on the ancient drawings as symbols of constellations. Astrologers were showing their students the

stars, calling stars either by their names (Regulus, Colossus, Arcturus) or by their position in the figure: the Horn of Aries (now its α), or the Claw of Scorpio (now its β), or the Heart of Hydra (now its α), etc.

But it was not a simple task to accurately mark the stars according to the limbs of imaginary animals, to remember them traditionally from age to age, and to carry them from country to country, not confusing the names in the night sky where no legs, arms, or tails could be seen. It was only possible for the stars of the 1st and the 2nd magnitude, the number of which in antiquity was considered 70... The stars of the 3rd magnitude, about 150 of which were visible in the sky from the coast of the Mediterranean, were already being confused with each other because the end of a leg or a tail of an imaginary animal - some teachers imagined lower to the right, others - higher to the left, and the stars of the lesser magnitude didn't count anymore...

Such uncertainty eventually led to the cataloging of stars. But even with cataloging, due to the imprecision of

ancient instruments, uncertainty remained, which for many stars of the 4th magnitude is not cleared up even in the list of «The Almagest»... At the longitude and the latitude it indicates down to 1/6 of a degree, sometimes there isn't any star at all, and among its nearest neighbors, not one but even two stars can be taken for it. And so, upon the invention of engraving, it became necessary (better say "possible" - *Auth.*) to publish a map of the starry sky, so anyone could study the sky besides its direct visual observation. That's what Albrecht Dürer (1471-1528), the famous Nuremberg painter and engraver, undertook at the end of the 15th century...» ([4], pp. 185-187).

We would like to emphasize, that before the invention of purely mechanical, stamped reproduction of drawings (engravings) in the 15th century, there couldn't even be a talk about detailed star charts. **Only mass production of absolutely identical copies could justify the labor of detailed depiction of the sky** down to the stars of the 3rd and 4th magnitude. Even if someone undertook the

titanic work of drawing such a map, it wouldn't persist through the ages at the very least because an exemplar of the map would quickly wither or rot, and to reproduce it would mean to repeat all the work from scratch.

We can see that Dürer's star charts indisputably appear to be the first detailed maps of the sky.

Therefore, **any document referring to these maps certainly belongs to the post-Dürer time.**

Dürer's mistakes

However, even a quick glance at Dürer's maps reveals striking features. Here's what Morozov writes about it:

«But Albrecht Dürer, although brilliant painter, was not an astronomer-observer, which is why, to preserve the grace of the figures, he allowed for several blunders on his charts. First of all, he... violated the uniformity of the length of the zodiacal constellations. When he saw that Virgo, as it would be depicted on the map, turned out disproportionately short

compared to her width, he stretched her legs, shortening the constellation Libra for it...

The second arbitrariness was how Dürer also drew Andromeda on the map in such a way, that upon a glance at the real night sky, it looks, more than anything, like a flag, waving on the colure of the vernal equinox...

Having thus moved Andromeda, Dürer, for the same artistic reasons, lowered the Urn of Aquarius under the ecliptic, reducing this constellation's length and disproportionally stretching the constellation Pisces because of that. Only constellation Scorpio remained within its exact limits, all the others are shifted almost uniformly from 2° to 5° to the right and to the left...» ([4], pp. 187-188).

Morozov returns to this topic later:

«...looking... attentively, the reader can see several clear evidence that Albrecht Dürer wouldn't always follow the real view of the starry sky but he just had a voiceless map before him at which he would look and then draw his figures

according to general instructions of the astronomer who determined them...

I have already said, how, to make the zodiacal figures look graceful, Dürer, for example, stretched the legs of Virgo at the expense of Libra and spread Pisces at the expense of Aquarius... Now I will draw your attention only to three particularly easily spotted discrepancies.

1. For example, here is the **constellation Altar** in the Southern Hemisphere... On a map, you wouldn't say much about it. But from the shores of the Mediterranean, look at it in the real sky, and you will see, that from the sunrise till the sunset it's hanging there bottom up, and its fiery tongue does not ascend to the sky, but descends to the ground instead... What real ancient observer of the sky was imagining it like this? Such orientation would seem ridiculous to him even if there wasn't a glow, rising up from the Milky Way and giving the idea of the fiery tongues on a heavenly altar.

2. And another example: the constellation of the flying stallion **Pegasus**. Again, it turns out very good on the Dürer's drawing, but on a clear night, try to carry this drawing over to the real sky and you will laugh out loud. From sunrise till sunset, Pegasus flies up there with its legs up like a bird shot by a hunter... It is absolutely clear that the ancient astronomers, not inclined to comicism, would never depict «the winged constellation of the spring» in such a caricature way. It was Dürer's yet another lapsus.
3. No less incongruity can be imagined in Dürer's depiction of the **constellation Hercules**, also standing in the sky upside down... (Morozov's book contains a reproduction of Dürer's drawing in question, and Morozov writes on its behalf: "As something especially interesting, I can add, that even with this particular drawing, it was a great difficulty for me but I managed to place it here upside down. Three times I was gluing it to proof-sheets as indicated by Durer and every time during editing the typesetter would persistently turn it to normal orientation." - *Auth.)*.

«...But especially important... is Dürer's erroneous depiction of constellation Virgo in lying position, considering, that in the real sky, it also has to set upside down every day, as if it throws itself from the heavenly height on the ground in a summersault...» ([4], pp. 203-210).

Further on Morozov notes and brings up corresponding drawings (see [4], p. 210), proving, that in ancient, pre-Dürer astronomies, the constellation Virgo is depicted in an upright orientation, although with a fantastical arrangement of stars. Its depiction (and depiction of other constellations) has very little in common with Dürer's drawings.

It is absolutely clear that the preparation of engravings on copperplate required enormous labor from an artist, and even if all these absurdities evoked horror in the author-astronomer, he had no choice anymore but to put all this «artistry» into print; especially since Dürer, who considered these maps a purely artistic work, could begin to distribute

the prints on his own, not waiting for the book to release (the engravings were produced in 1515).

Of course, Dürer's mistakes are quite natural: having only a flat map instead of a real view of the sky, the artist would draw to create a certain artistic impression. After all, if one would draw Pegasus correctly, on the figure it would be upside down...

Dürer's «Pegasus upside down» clearly bothered, for example, Copernicus. Keeping Pegasus' meaningless position in the sky, Copernicus in his stellar catalog changes the order of description of its stars. This appears to be the evidence of a subconscious struggle of the 16th century astronomers’ common sense against the meaninglessness of the Dürer's heavenly maps sanctified by Ptolemy's authority. No wonder, that in the ideological conditions of that time, authority won.

Thus, we must unconditionally recognize Dürer's authorship for all the absurdities and nonsensicalities in the arrangement of constellations. But hence it follows

inevitably, that any depiction of the constellations, that repeat the mistakes of Dürer, belongs to the post-Dürer time. Now let us apply this consideration to Ptolemy's work.

Apocryphal nature of The Almagest

In the text of «The Almagest» locations of less bright stars of the zodiacal belt are defined not with their coordinates, but with verbal descriptions like «the first of a couple on the horn of Aries», «in the mouth of Pegasus», «on the ankle of the right leg of Pegasus», etc., and it clearly follows from the text that these descriptions refer to the Dürer's pictures! Therefore, all these descriptions could have appeared in the text of «Almagest» only after 1515. Thus, **not just the star catalog, but even the text of «Almagest» was completed in the 16th century,** right before printing.

But "The Almagest" doesn't talk about the stars only. It deals with all the matters of astronomy (the theory of planets, eclipses, etc.). Could it be that in other places it still

bears incontrovertible evidence of ancientry? Alas, the answer again turns out to be negative.

Lunar eclipses

For example, consider the lunar eclipses described in The Almagest. Very briefly they are studied by Hinzel (see [16], pp. 229-234). A more detailed study, the main results of which we reproduce here, was performed by Morozov (see [4], pp. 448-474).

First of all, what draws attention is the extremely fragmentary nature of Ptolemy's reports on lunar eclipses and their wide scattering over the centuries:

- in the VIII century BC three eclipses (-720, -719, -719) were reported;
- in the VII century BC - one eclipse (-620);
- in the VI century BC - two eclipses (-522, -507);
- in the V century BC - one eclipse (-490);
- in the IV century BC - three eclipses (-382, -382, -381);
- in the III century BC - one eclipse (-200);
- in the II century BC - four eclipses (-198, -199, -173, -140);
- in the I century BC - no eclipses;

- in the I century AD - no eclipses;
- in the II century AD - four eclipses (125, 133, 134, 136).

Why are so few eclipses reflected? After all, lunar eclipses occur almost every year, and often even two in a year.

For example, in the II century AD lunar eclipses (visible in the Mediterranean) occurred in:

- 101 (twice)
- 112 (twice)
- 104, 105 (twice)
- 107, 108 (twice)
- 109 (twice)
- 111 (twice)
- 112 (twice)
- 113, 115, 116, 118 (twice)
- 119, 120, 121, 122, 123 (twice)
- 125, 127, 129, 130, 130, 132, 133, 134 (twice)
- 135, 136, 137 (twice)
- 138
- and finally in the year 139, which is indicated by tradition as the year when "The Almagest" was written;

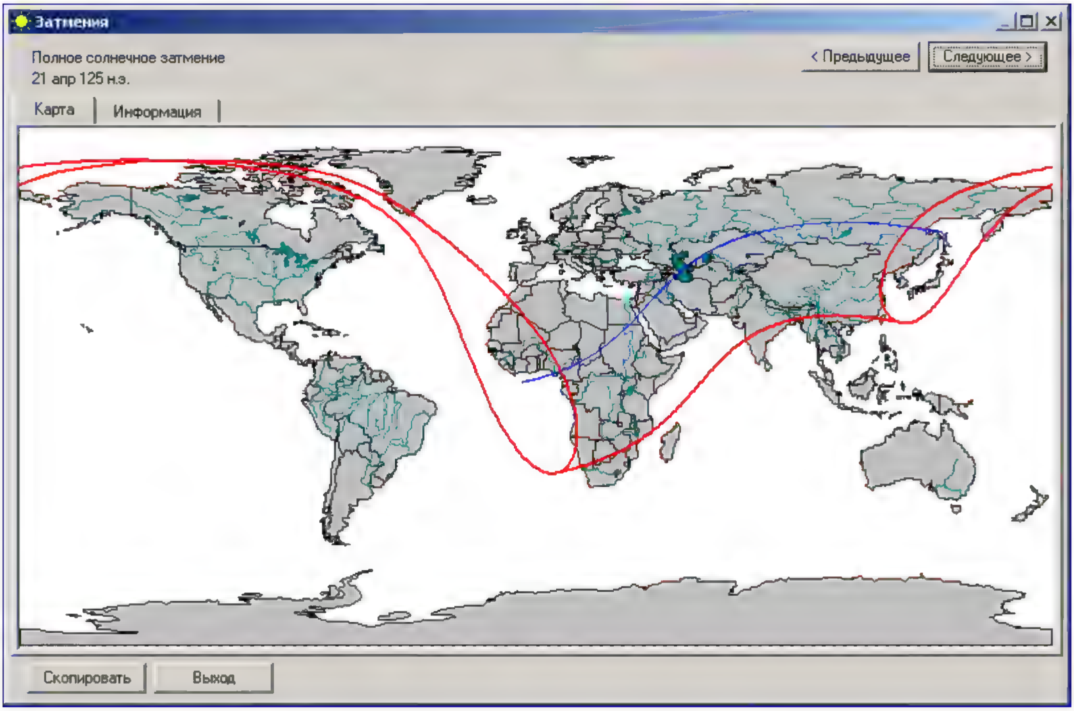
(41 times total).

How come a professional astronomer first constantly stresses that he has carried out his own observations («the eclipse observed in Alexandria in the 9th year of Hadrian...», «out of three eclipses, that we carefully observed in Alexandria...», etc.), and then he only indicates 4 out of 41 eclipses, and even among these, only one is total and other three are partial?

Careful reading of the text of «Almagest» allows us to answer this question. Describing technical characteristics of four eclipses of the II century (the moment of maximum phase, the phase itself, the date in the Egyptian calendar, etc.), the author of «Almagest» lets it slip that he precisely **calculated** these characteristics (see [4], page 467, where the full translation of this place is given). Hinzel, noting this statement of Ptolemy, has no doubt that the calculations were indeed carried out in the II century before the eclipse occurred. But after everything we already know about The Almagest, it makes sense to ask: were the calculations really carried out in the II century? The fact that these eclipses

were calculated seems indisputable (otherwise it is completely incomprehensible why other, non-calculated eclipses, aren't indicated). The author has stated a year, a month, and a day correctly, and for an hour he was only 45 minutes off. As for the statement about «personal observation», it is just as reliable as a similar statement about «personal observation» of stars and inserted in the text for the same reason - to cover up the apocrypha.

The apocryphal nature of the lunar eclipses of the II century also explains why Ptolemy, when he indicates «personally observed» lunar eclipses, never says a word about the incommensurably more spectacular eclipses of the Sun. For example, the circular solar eclipse of April 21, 125, whose maximum phase in Alexandria was at 10 AM. This solar eclipse occurred just two weeks before the lunar eclipse which Ptolemy described in detail. What professional astronomer could refrain from at least mentioning it?



(Here is the data for this eclipse from Zavalishin's "StarCalc". Not circular, as you can see... – Vadim Volkov)

Now everything becomes clear: the author of «Almagest» simply didn't know any solar eclipses of that time and couldn't calculate them either, because even in the 15^{th}–16^{th} centuries, calculation of the solar eclipse band appeared to be an incredibly difficult and quite uncertain task (unlike the lunar eclipses, whose prediction and calculation in those days was already carried out successfully).

As for the other eclipses (in the BC era), their identification by Hinzel is based on small, but quite definite stretches. For example, in Ptolemy's description, the very first eclipse (allegedly -720) occurred 6 hours too early.

Maybe these eclipses are calculated as well (an error of 45 minutes turned into 6 hours due to eclipses' greater distance in time), or maybe some other eclipses are described here.

We will not delve into this question (after all, the answer would be rather indifferent to us) and would simply point out that Morozov, definitely standing on the latter viewpoint, lists a series of eclipses after the AD, fitting the description given in «The Almagest» much better. These eclipses fall on the 5th–9th centuries AD, and so, if Morozov is right, one should admit that this part of «The Almagest» goes back to rather ancient sources (but still dated no earlier than the 5th century AD).

Summary

Let us repeat once again all our (or rather Morozov's) arguments in favor of the apocryphal nature of "The Almagest":

- incredible preservation of the star catalog (and, we would like to add, all the rest of the text of Almagest);
- inexplainable accuracy of this catalog (and other observational data of Ptolemy and Hipparchus);
- use of hard-to-calculate spring point to count longitudes
- the Latin edition's irrefutable 16th century AD dating (from star longitudes) – whereas the 2nd century AD dating, indicated in "Almagest" itself, gets confirmed by the Greek text only for the 16th century's idea of precession value but gets busted if the value is more accurate.
- Ptolemy's indication of the precession value, which appears to be the precession of the Jewish rather than the Julian calendar;

- «improved» star catalog data in the later, Greek edition, consisting of:
    - more precise coordinates of many stars (more remarkable ones mostly):
    - systematic correction of latitudes of stars, clearly intended to account for refraction;

- excessive systematic shift of the stars in latitude, both explanations of which point to the conclusion of the Almagest's apocryphality;

- Polaris being chosen as the first star of the catalog, which can't possibly be explained by the astronomical situation of the II century and conflicts with the ecliptical coordinate system adopted in "The Almagest";

- inclusion of the Achernar star, known beforehand as not visible in the II century Alexandria;

- descriptions in The Almagest, designating the positions of stars in constellations, being dependent on Dürer's drawings engraved as late as 1515;

- calculated essence of the lunar eclipses described in The Almagest and complete disregard for the solar eclipses of the II century.

Each of these circumstances alone can be explained – either way, using one or another stretch or ingenuity – within the framework of traditional ideas, but together they all form too heavy weight of evidence to possibly have any doubt about the apocryphal nature of "The Almagest" and its belonging to the 16th century.

In its ideas and level of factual knowledge, «The Almagest» appears to be a direct predecessor of the works of Copernicus, who published his book 6 years after «Almagest» and under its undoubted influence. **«The Almagest», therefore, appears as a simple summary of all astronomical information accumulated by the time of the 16th century.**

Since the name of Ptolemy is found even in the early medieval astronomical manuscripts, one can think that the legend of the ancient astronomer and philosopher who challenged God himself has an origin from very long ago. The scientific decorum and the tradition demanded references to Ptolemy but these references were reduced to meaningless curtsies, clearly revealing their authors'

complete unfamiliarity with «The Almagest» (except so-called «Arabic» astronomers al-Sufi, al-Ferghani, Abu-el-Wafa, etc., whose works we will analyze later when we will observe the history of the Arabic world).

It would be interesting to clear up (we have neither time nor possibilities for this), whether any astronomical, but clearly medieval manuscripts, attributed to Ptolemy, existed before the 15th century. Astrological ones do exist - «Tetrabiblos».

Whatever the case, by the 15th century the name of Ptolemy possessed complete authority, and printed works bearing his name began to appear. For example, in 1478 and 1482 "The Cosmography" attributed to Ptolemy was published, and in 1496, in Venice, Regiomontanus and Purbach published the book «The Reduction of the Great Creation of Claudius Ptolemy». Unfortunately, we do not have any information about this book, and, in particular, whether it contains a star catalog, and if it does, then in what form. It is possible that it was the first version of "The Almagest".

The Author of Almagest

So who was the true author of “The Almagest”? This is a difficult question, which can only be answered when details of the history of The Almagest's publishing will be known (for example, we would like to know, who offered to publish “The Almagest” and who brought its «translation» to the publisher; this information is not in the available literature). Morozov thinks that the author of “The Almagest” was George of Trebizond himself. But this is very doubtful.

According to available data, George of Trebizond was a man of humanitarian education, a teacher of rhetoric and philosophy, and an adherent of Aristotle. He allegedly translated “The Almagest” in 1451. He died in 1484. Even though Morozov doubts the date of his death (pushing this date by 50 years, to 1515 at least), and even considering, that in the era of widespread encyclopedism, George could really know astronomy, we still should look for the author of “Almagest” among astronomers before anything else.

Involuntarily, the name of mathematician and astronomer **Johannes Müller** (1436-1476), usually called **Regiomontanus**, comes to mind. He was a man of boiling energy and, apparently, extraordinary talent. The 500 years since his death (he died young, from the plague, in the rank of bishop) recently were noted solemnly in Nuremberg.

Regiomontan's activity is still clearly underappreciated. Historians of mathematics are reticent about him, only noting that he was the first to separate spherical trigonometry from astronomy and he also has compiled the sine tables. Historians of astronomy, noting that he has performed many astronomical observations (we shall note, with instruments described by Ptolemy), value him first of all as a publisher of astronomical books and tables (used by Columbus, for example), distributor of the ideas of Ptolemy and translator of his books (see e.g. [98], pp. 194-196). As Berrie writes, «his brief life was spent almost entirely in the studying and commenting on the Greek astronomy...» ([99], p. 128).

Actually, we shall consider Regiomontanus as **the creator** of «the Greek astronomy», or at least as the finalizer of the studies of his predecessors (curiously, his teacher Purbach (1423-1460) appears to be the author of the malicatively titled study «The New Theory of The Planets», containing the epicycle theory). Regiomontanus' early death prevented the publication of his compositions.

Although Regiomontanus was in Nuremberg for less than five years, in that time frame he managed to establish an authoritative school of astronomers there, which existed till the 17th century. His friend and apprentice Walter (1430-1504), who financed many undertakings of Regiomontanus, preserved his manuscripts carefully, and in 1496 prepared for printing the aforementioned «Reduced Almagest», whose composition was started by Purbach long ago and completed by Regiomontanus.

After Walter's death, Regiomontanus' manuscripts with a commentary on "The Almagest" went to Pirkheimer, and finally were published in Nuremberg, already after the

publication of The Almagest (1541 and 1550), i.e. at the exact moment when they became significant.

We do not know who among apprentices of Regiomontanus ordered engravings from Dürer (wasn't it Werner, who died in 1528?) and who in 1537-1538 prepared "The Almagest" for printing. The connection between Regiomontanus and George of Trebizond is unclear too (apparently nobody even raised the question of whether they could work together). It is also not of little interest that in the 15th century, Nuremberg was indeed the center of the production of precision clocks (the famous «eggs of Nuremberg») and that Dürer lived and worked in Nuremberg.

§ 3. Lunar, solar, and lunisolar calendars

Understanding the problems of chronology requires understanding the structure of possible calendar systems. We will present the relevant material here because it provides us an opportunity to dispel yet another myth, this time associated with the name of Hipparchus.

Tropical and calendar year

The astronomical solar year should have been defined as a period of time from the vernal (or autumnal) equinox to the next vernal (or autumnal) equinox. However, it turns out that the "spring year" is somewhat (about 90 seconds) different from the "fall year", and both years slowly change over time (the same 90 seconds get accumulated over 5-6 thousand years). Therefore, astronomers introduce a certain conventional average year called the *tropical year.* According to the modern data, the tropical year is equal to:

365.2422 days = 365 days 5 hours 48 minutes 46 seconds

As we have already said, one of the main requirements for a calendar is its climatic character, i.e. its consistency with the production seasons and times of the year. In such a calendar, the beginnings of the seasons (winter, spring, summer, fall) should always fall on the same quite certain dates. However, in practice, it is impossible to satisfy the condition of climaticity with absolute accuracy. Therefore, one has to resort to approximations.

To find the best approximations of the number of days of a tropical year, it is necessary to decompose this number into a continuous fraction according to the well-known rule of arithmetic:

$$365{,}2422 = 365 + \cfrac{1}{4 + \cfrac{1}{7 + \cfrac{1}{1 + \cfrac{1}{3 + 1/4}}}}$$

from which we find successive matching fractions:

$$365 = 365{,}0000$$
$$365\ 1/4 = 365{,}2500$$
$$365\ 7/29 = 365{,}2414$$
$$365\ 8/33 = 365{,}2424$$
$$365\ 31/128 = 365{,}24219$$

The easiest way to achieve this length of the year is to count the main calendar year as 365 days and increase the individual (leap) years to 366 days.

If we would take the zero approximation of 365 days, then, naturally, we wouldn't have any leap years at all, but the calendar would be completely unsatisfactory. Every four years it would accumulate an error of 1 day.

A much better result can be obtained from the first approximation of 365 1/4 days. This is the well-known **Julian calendar** *(old style)*, in which every fourth year is a leap year. It gives an error of 1 day after 128 years only.

The next matching fraction leads to a calendar with 7 leap years every 29 years. It gives an error of 1 day in 1250 years. This calendar has never been employed.

The third matching fraction 365 8/33 gives a calendar with 8 leap years every 33 years. It is said to have been introduced by Omar Khayyam in 1079 AD and used in medieval Iran. Its accuracy is 1 extra day in 4500 years.

The last suitable fraction was the basis of a calendar proposed by Medler about a hundred years ago. Theoretically, it is perfect, giving an error of 1 day in 100’000 years, but in practice, of course, nobody needs such accuracy.

It is interesting, that the **Gregorian calendar** *(new style)* that we use now does not belong to the number of calendars recommended by mathematics. Every 400 years it lets out 3 leap years from the Julian cycle and so corresponds to a fraction:

$$\mathbf{365\ {}^{97}/_{400}}$$

and gives an error of 1 day in 3280 years. Its «unmathematicality» comes out in the middle of the cycle, when the error can reach one and a half days until it will be destroyed by the leap year, while in the "mathematical" calendars this error never exceeds half a day. (in the last chapter it was mentioned that astronomers stick to Julian because of the more regular leap year system – tr.)

Synodic and calendar month

Of course, the solar year is too large a unit for ordinary use. Smaller units - week and month - arose in connection with the phases of the Moon. The week ended up outside any common calendar systems, so we will not observe it.

On the contrary, the counting of lunar months (from new moon to new moon) is the basis of many calendar systems. The average interval between two new moons is called a *synodic month.*

Its modern value:

29.5306 days = 29 days 12 hours 44 minutes 3 seconds

Since, unlike the position of the Sun, the phases of the Moon have no economic significance, we must think that the lunar month had a sacred meaning from the very beginning. At the same time, due to the general syncretic character of ancient societies, this month was, apparently, used for civil purposes too, since the most ancient times.

However, a usual difficulty arises here. Because of the complex and irregular motion of the Moon, the *neomenia* (the first appearance of the lunar sickle after the new moon), from which the lunar months can be counted, is very difficult to predict reliably. That is why sources report that, for example, the calendar of the ancient Jews was completely dependent on the observation of the neomenia, and the beginning of each new month was proclaimed by a special decision of the Sanhedrin. Such a system (strictly speaking, not appearing to be a calendar) may be quite suitable for the needs of a cult; however, it is absolutely unsuitable for orderly state and household activity. That is why the authors of the Julian calendar, having borrowed from the lunar calendars the idea of approximately a 30-day month, completely ripped it off from the phases of the Moon (on this basis the Julian calendar is called *purely solar).*

The civil calendar with lunar months became possible only when astronomical observations (long enough and, therefore, already based on the Julian calendar) revealed the patterns in the motion of the Moon, necessary for the

creation of a formal lunar calendar, independent of the monthly observations of the neomenia. We see that such a calendar cannot precede the Julian calendar.

It is believed that the *Muslim lunar calendar* (the only lunar calendar functioning currently) was introduced in 638 AD (in the 16th year of the Hijra) by Caliph Omar. For purely calendrical reasons **this information is very doubtful**, at the very least because this calendar is unusually accurate (it gives an error of 1 day in 2500 years) and possesses a complex leap year system, which could be thought up only on the basis of sufficiently advanced science (besides, there are two such systems: "Arabic" and "Turkish").

In Chapter 15 we shall see, that, in fact, this calendar was introduced relatively late (not earlier than the 12th century AD). This is confirmed, in particular, by the fact that the vestiges of the custom of the neomenia's observation persisted in Muslim countries until very recently. The Muslim calendar is the only widespread calendar that has rejected the climatic principle completely (its year is 11 days shorter

than the tropical one). Its introduction owes solely to the pressure of religion. However, despite this pressure, its blatant economic unsuitability led to the emergence in the Islamic countries of the so-called "solar Hijra" - a variant of the Julian calendar with the beginning on March 21, 622 AD.

Lunisolar calendars

From the attempts to combine the lunar month with the solar year (and thus obtain a climatic calendar) the so-called *lunisolar calendars* arise. Such a combination is, of course, a very difficult matter, and it may be thought that originally it was, quite as tradition asserts, carried out by the method of arbitrary insertion of the thirteenth month. It is undeniable, however, that such "chronology" could be used for very limited, apparently purely sacred purposes only. Claims that it was used by the state-fiscal apparatus we must regard as laughable. But maybe, in some extreme cases, the method of arbitrary insertion could have been used by the state for a very limited time just before the introduction of an organized regular calendar.

Besides, it should be kept in mind that the very discovery of the necessity of the thirteenth month is impossible without comparison to some regular, i.e. Julian, calendar. The "climatic" theory proposed by Idelson (see [21], p. 117) can only cause a smile.

Therefore, we can safely consider any information about the existence of state lunisolar calendars in the "pre-Julian" era as apocryphal.

Assuan Documents

This conclusion would seem to be contradicted by the ten Aramaic papyri discovered in 1904 in Assuan, Egypt, and dated 5th century BC. «Despite their 2,300 years' age, in the degree of preservation, they make an impression of having been written the other day. Their domestic significance is immense: it is something like the family and property archive of two generations of a Jewish family that arrived in Egypt, as we may think, following the armies of Darius of Persia (500 BC). The time period that they cover is 60 years (from 471 to 411 BC). For the chronologist, the special

importance of these documents lies in their parallel dating, in particular, according to the Jewish lunar and Egyptian solar calendars" ([21], p. 118).

Idelson gives an example of such dating: «Kislev 21, that is, Mesori 1, in the year 6 of Artaxerxes», and further writes that «based on the data of Ptolemy's canon, it's not difficult to calculate that Mesori 1... fell on November 11, 459 BC» ([21], p. 118), forgetting to note that besides the data of the canon, this calculation also requires certain hypotheses about the Egyptian «wandering» year. Identification of November 11 as Kislev 21 means that 20 days elapsed from neomenia to November 11. Hence, on October 22 there was a neomenia. However, it turns out that «the scribe undoubtedly made a mistake», since the new moon in October of 459 BC was actually on October 10. But repeating the calculation for the year 5 of Artaxerxes, Idelson gets the date October 22, whereas the astronomical new moon was October 21. He regards this as a «great match», and concludes with a notion that «the dating of

other papyri also give satisfactory agreement» (see [21], pp. 118-119).

But in reality, it is clear, that even if there is something these papyri prove (their authenticity is absolutely not obvious), it can only be the complete falsity of the traditional chronological grid. And when it comes to reference to the scribe's mistake (That is in a property document, come on!), anything can be «proven» like this. By the way, it is the insignificance of the error (just 1 year off) that makes one suspect a forgery: the falsifier could easily let such a miscount in his calculations.

Metonic Cycle

The task of constructing a lunisolar calendar is based on the comparison of two numbers: the length of the tropical year (365.2422 days) and the length of the synodic month (29.5306 days). It is believed that long ago, in 432 BC, the Greek scholar Meton discovered, that if we take 6940 days and distribute them across 235 months, of which 125 months are 30-day and 110 months are 29-day, the average

length of a month would actually match the synodic month (with an error, as we know now, less than 2 minutes). At the same time, if the same 6940 days are distributed over 19 years, the average length of a year would also be virtually equal to a tropical year (with an error of about half an hour). Thus, according to Meton:

19 solar years = 235 lunar months

This ratio (known as the «Metonic cycle») is the basis of virtually all lunisolar calendars and is «justly considered one of the masterpieces of Greek astronomy» ([21], p. 124).

Calippic Cycle

However, the average length of a year, taken according to Meton, is too long. Therefore, allegedly Calippus in 330 BC proposed to take a block of four Metonic cycles and in it to turn one full (30-day) month into a 29-day one.

Thus «the cycle of Calyppus» consists of 27759 days (4x6940-1) spread over 76 years (4x19), or, otherwise, spread over 940 months (4x235) of which 499 months are full

(4x125-1) and 441 (4x110+1) month is incomplete (empty). The cycle of Calyppus gives an exact Julian year of 365 1/4 days, and in the synodic month, it allows for an error of mere 22 seconds.

Hipparchic Cycle

Finally, as if in 125 BC, Hipparchus proposed to take a block of four Calippic cycles, and in the same way shorten it by 1 day. This gives an absolutely accurate synodic month and reduces the error in the year to 6.5 minutes.

To find the Metonic cycle (not to mention the cycles of Calyppus and Hipparchus), it is necessary to know the synodic month and the tropical year with accuracy, which with ancient instruments could be achieved only after many years of continuous astronomical observations, and, therefore, only on the basis of the regular Julian calendar. This immediately makes the traditional date of 432 BC fantastic and puts the discovery of the Metonic cycle to a time no way earlier than the 6-10th centuries AD, i.e. exactly when the lunisolar Jewish calendar, based on the 19-year

cycle indeed, took shape. Traditionally, this calendar was considered to have been introduced in 490 AD. However, in the 19th century Hayyim Selig Slonimski, the famous historian and researcher of the Jewish calendar, proved that it occurred in 953 AD (see [4], p. 152).

Idelson's reconstruction

This objection to the traditional dating of the Metonic cycle was certainly known to Idelson (for a time, he worked together with Morozov), and therefore Idelson tried to prove(see [21], pp. 121-124), that to discover his cycle, Meton did not need great accuracy at all and it was enough to know the solar year of 365 1/4 days and the synodic month of 29 1/2 days. Not dwelling on the fact that even this little accuracy would be difficult to achieve without the Julian calendar, nevertheless, let us discuss Idelson's considerations on their merits.

Here's how Idelson reconstructs Meton's reasoning:

"The crudest observation shows that 3 years (1095 days) correspond to about 37 lunar months (12x3+1); and indeed, turning them into 19 full months and 18 empty, we do get 1092 days (19x30+8x29).

(Why won't you take 22 full and 15 empty months, which would give you 1095 days exactly? - *Auth.*).

More accurate observations (not astronomical but arithmetical - *Auth.*) lead us to the compilation of the 8-year period (which is known in the literature and attributed to the astronomer Cleostates, who allegedly lived in the 6th century BC - *Auth.*); in fact, taking 99 months and turning them into 51 full and 48 empty months, we find 51x30+48x29 = **2922** days.

But 8 years (365¼ x 8) also make up **2922** days; so, after the Sun's 8 returns to the equinox, the Moon must return to its original phase.

Now let's try to combine the 3- and 8-year periods into one united 11-year period; then combine the 8- and 11-year periods into a new 19-year period. (Arithmetically, this corresponds to the formation of intermediate fractions...)." ([21], pp. 121-122).

But it turns out «that such layering of periods doesn't get us anywhere; the error (calculated from the modern data – *Auth.*) increases all the time. However, we can easily correct the matter, namely, by defining the 8-year period as equal to 2924 days, which, as we know (now we do! - *Auth.*), is closer to the truth, than 2922 days. For this purpose, it is sufficient to make two empty months full...» ([21], p. 123). The result is the Metonic cycle indeed.

It is surprising how the astronomer, i.e. a person who should have long been accustomed to strict logical thinking, does not see gaping holes in this «reconstruction». He

constantly reasons from the modern viewpoint and cannot put himself in the place of the ancient astronomer. Let us try to do it ourselves.

Suppose we know that a tropical year consists of 365 1/4 days and a synodic month consists of 29 1/2 days. We may suspect that these numbers are inaccurate, but we still do not know the limits of the error. Then, what can we say about the periods found by Idelson?

The 3-year period is certainly not bad (especially if you increase the number of full months to 22), but it's not quite accurate since 3 years consist of 365 3/4 days (each?-tr.).

On the contrary, the 8-year period is *perfect*, giving exactly the required length of year and month.

The periods of 11 and 19 years are *worse* than the 8-year period, as they contain an inaccurate 3-year period.

Lengthening the 8-year period by 2 days spoils the period and does not make the 19-year period good (the

year turns out to be less than 365 1/4 days and the month – to be more than 29 1/2 days).

Thus, reasoning exactly according to Idelson, the ancient astronomer should have accepted the 8-year cycle (which, apparently, occurred indeed, except not in the 6th century BC but in the 6th century AD) and should have rejected the 19-year cycle. And later, only after observations clarifying the duration of a tropical year and a synodic month, the Metonic cycle finally did become possible (by the 10th century AD).

And on the matter of cycles of Calyppus and Hipparchus - of course, they belong to even later times. Trusting the information that the so-called Alphonsine Astronomical Tables, giving the tropical year with an error of less than a minute, were really compiled in the 13th century (and not in the 15th century by Regiomontanus), Hipparchus (his year differs from the true year by 6 1/2 minutes only) would fall on the 10-11th centuries. Otherwise, he is pushed to the 15th century.

Morozov’s additional considerations

Before the spread of Christianity and its cult of saints, all names always had a definite meaning and a certain sense. The name "Meton" appears to be a remarkable exception and has no meaning in Greek, which alone proves its fantasticality. Morozov believes (see [4], p. 155) that it comes from the Hebrew “MTN” - «gift», and therefore «Meton cycle» simply means «gifted cycle» (apparently, gifted by God so it would be possible to create the Jewish calendar).

Morozov also points out, that according to a Jewish legend, the inventor of the «gifted cycle» was not Methon, but the Jerusalem high priest Hillel the Great, who allegedly lived in 333-370 AD. One can doubt that Hillel actually knew the Metonic cycle: according to all the data above, the cycle was found long after the 4th century AD. However, regardless of all previous calendar-astronomical considerations, this information points to the 4th century as the lower boundary of the formulation of the Metonic cycle.

§ 4. Origin of "ancient" scientific literature

The mechanism behind the creation of scientific treatises

In the example of the Almagest, we can see that the statement about the apocryphal nature of ancient literature is also fully applicable to scientific books. However, in regard to natural scientific (and, in particular, mathematical) works, the question of their authorship is particularly acute. It's easier with humanitarian works because for them we can either directly indicate the supposed author, or outline a circle of people who could be him by their education, culture, and literary talent. However, this is not the case for, say, Euclid. Who among the scientists of the Middle Ages could claim this role?

Morozov writes:

"After the invention of rag paper but before the advent of the printing press, every scholar copied the books of his predecessors for his own use only, and therefore corrected unclear places, throwing out anything he considered wrong, and, first of all, supplemented the copy with his own information and reflections. With each new rewriting, the original text of the works beyond the control of the church was adapted to the ideas of the new time and was growing in volume. A process of collective creation was taking place, in which, of course, the work kept the name of the original author. Something similar happens with modern textbooks even now: new discoveries made by science are being added to them constantly, but a part at their core remains the same.

...The scientist, rewriting the book for himself and with additions, quite rightly signed it with the name with which it had been marked before. "Euclid's Geometry," - he would note - without mentioning that he had added two or three

new theorems of his own and better justified one or another of the old ones. This way he was providing the next copier of his manuscript with an excuse to add two or three new theorems as well, also keeping the textbook's former name. And so, as the centuries passed, a small dozen of theorems, which could really be collected by one man of that name (the name "Euclid" means "well-dressed" or "well-bound"), was turning into a large book, well-developed in all of its detail. However, the subsequent scientist, having lost sight of this ages-long process of improvement, attributed the entire collective creativity to a single ancient giant of geometrical science, and at the same time defined an erroneously high level of knowledge in the very ancient times. In fact, *the entire book represented the sum of the knowledge of the entire historical period*, that lasted until the printing press distributed the book everywhere for the first time and established the time and place of its first edition" ([4], pp. 174-175).

The described mechanism of unconscious collective creativity explains well the origin of such comprehensive treatises as Ptolemy's "Almagest" or Euclid's "Elements", as well as the fact that references to them were possible long before their text was finalized. It does not suggest any overt deception and mystifying intentions on the part of the authors and publishers, although this possibility definitely cannot be ruled out.

One has to keep in mind, that at the dawn of printing, the rules of publishing "ancient" texts were clearly different from modern ones. As the example of "Almagest" shows, editors and publishers of the final text did not hesitate to make amendments and additions corresponding to the latest state of science, without specifying it in any way. Wasn’t it the reason why the "translation" of scientific books was often preceded by a "bad translation" that did not contain these amendments and therefore reflected the previous stage of scientific development?

History of "discovery" and publication of "ancient" mathematical manuscripts

(Euclid, Diophantus, Archimedes, Apollonius)

The history of the "discovery" and publication of "ancient" scientific treatises is in all essential features similar to the history of humanitarian works.

Here, for example, is what Prof. Vygodsky writes about **Euclid's** "Beginnings":

"The antique manuscript of Euclid's "Beginnings" hasn't come down to us except for a few small passages found in excavations in Egypt and Herculaneum. The oldest manuscript known to us is a copy made in 888 by the monk Stephen for the Archbishop of Caesarea. There are many manuscripts dating from the 10th to 12th centuries. **Apparently**, they were all made in the Byzantine Empire and reached Western Europe much later. It is also unknown how many intermediate copies lie between these manuscripts and the original source" ([70], p. 224).

One can easily understand where this lovely "apparently" comes from. According to traditional ideas, in the 9-12th centuries, the level of mathematical knowledge in Europe was so low that it is impossible to speak seriously of even a single reader of Euclid in those times; and about the mathematical culture of Byzantium, nothing substantial is known.

It is strange that Professor Vygodsky does not pay attention to a fact that follows from his own words and appears to be amazing for the history of mathematics: in the 9th century Byzantium already possessed first-class mathematicians (the same "Bishop of Caesarea"), understanding and interested in Euclid!

The most interesting is the situation with **Diophantus**. Bashmakova, a specialist on Diophantus, in her introductory article to the Russian translation of Diophantus' "Arithmetica", reports that even before the publication of the first Latin translation of "Arithmetica", European...

"scholars used algebraic methods of Diophantus, without being familiar with his works" ([60], p. 25).

Bashmakova characterizes this situation just as "somewhat paradoxical" (!). Well, well, God is her judge.

Like the Almagest, the work of Diophantus was initially published in 1575 in Latin translation, and it was not until 1621 that the famous Bache de Meziriac published the Greek text for the first time, supplemented with an "improved" Latin translation. Like the Almagest, Diophantus contained essentially the entire stock of information accumulated by science by that moment, and so, just like Ptolemy was immediately continued by Copernicus, Diophantus was soon continued by Fermat (1601-1665).

In light of all this, the figure of **Archimedes** is also very interesting. Apparently, like the name of Ptolemy, the name of Archimedes was known for a long time, but everyone imagined him however he pleased. This is indeed the only way to understand the traditional information that Cicero knew Archimedes only as an engineer and "discoverer of

numerical ratios", and Titus Livy - only as an astronomer and designer of military machines (see [68], p. 52).

The works attributed to "Archimedes" are so diverse that for some of them, historians even have to reject Archimedes’ authorship (see [68], p. 622).

The history of manuscripts and printed editions of Archimedes tediously follows a pattern we already know. In the introductory article to the Russian edition of Archimedes' works, Professor Veselovsky reports that the basis for all modern editions of the texts of Archimedes is a lost manuscript, that belonged to George Balla in the 15th century and also (this is something new!) a Constantinople palimpsest found by Heiberg in 1907:

"The works of Archimedes got in Western Europe only after the Constantinople pogrom of 1204, and that's probably when the manuscript, which was later at George Balla, was transported to Europe. The first translation of Archimedes' work into Latin was made by William of Moerbeke, the Franciscan and a friend of Thomas

Aquinas. This translation, completed in 1269, was not found by Rose in the Vatican until 1884. This translation... is literal... but the Franciscan scholar was hardly versed in the substance of the matter. Part of the translation from Moerbeke was printed by Luca Gauric in Venice *in 1503* (the first printed edition of Archimedes' works). But this edition went so unnoticed that the famous Tartaglia boldly appropriated it to himself and published it in 1553 and 1565 as a "translation from Greek."

The second Latin translation of Archimedes was made by Jacob of Cremona around 1450. In 1468 it was transcribed by the famous Regiomontanus and brought to Nuremberg for publication. However, Regiomontanus' early death prevented him from fulfilling his intention, and the first edition of Archimedes' Greek text was not published until 1544, in Basel, based on manuscripts derived from the text of George Balla. After that, Archimedes' works enter the commonplace of the scholarly world"

([68], pp. 54-56).

Archimedes is repeatedly quoted by Leonardo da Vinci even before the publication of Archimedes' works. Here is what Prof. Markushevich says:

"...Leonardo da Vinci, whose notes repeatedly mention Archimedes, could only learn about him from a manuscript. But Leonardo did not know Greek and had no solid skills in Latin..." ([100], p. 54).

Strangely, Markushevich confines himself only to stating these facts.

Markushevich also writes regarding **Apollonius** there – the third most important ancient Greek mathematician:

Apollonius' "Conic sections" went out of print in 1537, and only in the form of four early, the most elementary books

(the rest just weren't written yet - *Auth.*)

Kepler, who first discovered the importance of conic sections (ellipses) for astronomy, did not live to see the full edition of Apollonius' work. The next three books of the Conic Sections *were initially published in Latin translation in 1631*" ([100], p. 54).

Thus, Apollonius' complete work on conic sections came out only **after** Kepler discovered the value of all these conic sections! Most likely, this work was written after Kepler indeed, and attributed to the "ancient" scientist to ensure the book's popularity. Perhaps, the unknown author simply did not dare to compete with Kepler and publish the book in his own name.

Causes of Apocryphal Research Papers

By the way, here's what Markushevich writes about the difficulties of publishing books in those days:

"...If a publisher was deciding to take a risk and undertake a large and expensive labor of publication (a substantial part of the costs, sometimes over half, was the cost of paper), it was necessary for him to count on an appropriate number of interested readers, at least about 300, considering those days' limited circulation. But such a large group of highly competent mathematical scientists didn't exist not just in the 15th even in the early 16th century... A peculiar example of a major scholar of the 16th

century who was outright *unlucky* with printing his works was Francesco Maurolico (1494-1575): a mathematician, mechanic, optician, and historian. His... *translation of Apollonius* appeared in 1654, and his original work on optics, anticipating Kepler in many respects, did not appear until 1611, 7 years after the publication of Kepler's own work" ([100], pp. 55,56).

Morozov talks about this in greater detail:

"The printing press immediately created book markets, but they still were isolated from each other because of the difficulty of distant communication and the released books didn't have any rapid publicity. But of course, none of them (the first book publishers – *Auth.*) could hope to reap great benefits from printing the scholarly works of their acquaintances, because in their own town, there could be only a handful of buyers for these works, and in other towns there was none at all. The point is that nobody knows a person, who's just publishing his first work, and back then,

the book was still too expensive for literate people to risk and buy the work of an unknown person.

What was happening here was the same thing that sometimes happens even now, to novice writers and scientists especially. Publishers refused to print the works of an author who wasn't famous yet, but the author could become famous only after his works were published. Even nowadays, junior writers can hardly solve this dilemma by introducing themselves to the reader through articles in magazines or by prefacing the book with a foreword by a celebrity. However, in the first 200 years of printing, even these kinds of things were impossible. There were only two methods left, vivid traces of which we can indeed see in the works of the 15th and 17th centuries.

While I was still a gymnasium student, I read scientific works and on the first pages of them there were all these lavish dedications to dignitaries... I resented it... And only much later, when I understood the thorny path of the ancient scientific author, I saw, that in the name of science

itself, the ancient authors had no other choice. After all, the person to whom the book was dedicated, was its true publisher indeed, and materially disinterested at that. This count or prince who was interested in the work and was not without an ambitious desire to connect his name with it, was the one giving its author material means for it or at least the one guaranteeing the publisher his break-even.

But besides this way of getting his book into print, there was another: to pass off one's own work as a manuscript remained after one’s ancestors and written by some ancient, maybe purely legendary celebrity. Even if the publisher suspected the apocrypha, he still willingly agreed to print the book, expecting that in such case it would certainly spread, and maybe even advised the author to use such a technique. Sometimes the author had no other way though: either he could leave the fruits of many years of his thought and sleepless nights to eternal oblivion or could present them to the world in the name of another person, without any hope of attaching his name to it, except as the

one who found this work, or its translator, or, at least, a renewer of anachronistic places..." ([4], pp. 176-178).

Aristarchus of Samos

Of course, there could have been other reasons for apocryphal writing: for example - a fear of persecution. A striking example is the work "On the System of the World, its Parts and Properties" by **Aristarchus** of Samos, published in 1644.

"Aristarchus of Samos (late 4th - early 3rd century BC) was an outstanding astronomer of antiquity. Archimedes begins his "Psammites" with an excerpt from "Propositions" – an Aristarchus' nonextant work. But from the excerpt, one can easily imagine the system constructed by Aristarchus: "(Aristarchus) believes that the fixed stars and the Sun do not change their place in space, the Earth moves in a circle around the Sun, which is in the center of the circle, and the center of the ball of fixed stars coincides with the center of the Sun." From these lines, it is evident that Aristarchus's

system is nothing else than the system laid by Copernicus at the foundation of his own work" ([76], p. 186). On the basis of this Archimedes' indication, Aristarchus is called "The Copernicus of the ancient world", although in his only extant work "On the magnitude and distances of the Sun and Moon" Aristarchus actually adheres to the geocentric viewpoint" (see [68], p. 598).

And about the said book "On the System of the World..." dedicated to the propaganda of Copernican views, historians of science write:

"From the title of the book it seems to follow that its author is Aristarchus. But in reality, it is a disguise maneuver of Roberval

(famous French mathematician of the 17th century – *Auth.)*

Roberval wished to present an essay supporting the Copernican system of the world. However, the fresh memory of Galileo's trial and his ordeal made Roberval cautious: he presented his work as a translation from an Arabic manuscript, which enabled him to omit Copernicus' name

and shifted the responsibility from the original author to Aristarchus" ([76], p. 186).

After all the above, comments are superfluous. However, it would be interesting to figure out: did Roberval also come up with the very name "Aristarchus"? If he did, then, consequently, "Psammites" was written after 1644. It is possible, however, that the legend of the "Copernicus of the ancient world" predates Roberval (e.g., to support Copernicus' teaching with ancient authority), and Roberval simply used a convenient screen.

Roberval was not very secretive about his authorship either:

"It's unknown whether this hoax had the expected result in regards to the church authorities, but among scholars, Roberval's authorship was widely known" [76],p.185

But what would have happened if Roberval had been more thorough with preserving his incognito, or if he had not been such a well-known scholar? Wouldn't we possess another "miraculously survived" ancient work, existing only as a printed edition with a hopelessly "lost" original? Keep in

mind that all of it happened very late, in the 17th century! So what right do we have to trust publications released 100-200 years earlier?

Conclusion

1) We have described the reasons for the apocryphalization of scientific works of antiquity;

2) We have indicated a possible mechanism for the creation of encyclopedic works in the Middle Ages, during which we don’t know any geniuses capable of writing them;

3) We have confirmed once again that the actual history of the publication of manuscripts does not possess any evidence in favor of their antiquity. On the contrary, there are numerous indications of their apocryphality.

Of course, taken individually, these considerations do not prove apocryphality, but, at any rate, they show that the previously proven apocryphal nature of, say, the "Almagest", is not as shocking a fact as it may initially seem.

Addendum. Amphorae volume formula

Classical chronology has a property that can be called "instability". It consists of the fact that new finds - usually random and isolated - often lead to a revision of the chronology by several centuries. Examples of new finds that caused the shift of the entire chronological grid by a few centuries will be given in Chapter 7, but only for biblical chronology. In antiquity, the general grid usually is not touched, but historians have no problem with shifting individual events by two or three centuries. A very interesting example, revealing another type of contradiction in ancient history, is connected with the problem of classification of ancient Greek amphorae (see [152], pp. 37-38).

Heron of Alexandria gives a formula for the approximate calculation of volumes of bodies of rotation, which uses the "Archimedian" value of the number π=21/7. Nothing is surprising in this, since, according to traditional chronology, Archimedes lived in the 3rd century BC, and

Heron lived something like three hundred years after him. There is also nothing surprising that, as modern research based on extensive statistical material has shown, Heron's formula was used to calculate and standardize the volume of amphorae. What is surprising is that many of these amphorae date back to the 4th, 5th, and sometimes even 6th centuries BC!

"So, the formulas for very accurate calculation of volumes of complex bodies of rotation were widely known and applied in practice long before Heron and Archimedes. Who was the author of these formulas, we will most likely never know. However, this ancient mathematician lived, in any case, in the 6th century BC, that is, at least five or six centuries before Heron and three centuries before Archimedes. But there's more, it turns out that the very precise value of π, completely corresponding to the Archimedian value, was calculated not just long before Heron, but even long before Archimedes, whose merit it has been considered to be up to now. It may be supposed, that in his work, Archimedes, like Heron, set forth not the result of his own discovery, but the result of the calculations of his

predecessors, which, perhaps, will remain anonymous forever" ([152], 38).

This conclusion belongs to a humanities historian. But any qualified historian of mathematics would reject such a conclusion with indignation. Even in the 3rd century BC the Archimedean proof of the formula $\pi = 3\,{}^{1}/_{7}$ was far ahead of its time, and in the 6th century BC it was plain impossible (just like, for example, the work on the group theory was impossible in Newton's time). And without an appropriate method at one's disposal, one can neither derive this formula nor guess about it.

Here one can see how the history of mathematics enters a hopeless conflict with the history of material culture. Resolution of this conflict through local variations of chronology is clearly impossible.

§ 5. Consequences of apocryphing medieval science to ancientry

Exaggerated idea of ancient science

The primary consequence of the apocryphalization of medieval science to ancient times is, of course, an exaggerated idea about the capabilities and achievements of ancient science. Cautious attempts to shake the generally accepted opinion on this issue have been repeatedly made by specialists who realize their absurdity but see no alternative to traditional chronology. For example, here's what the famous historian of ancient science Neugebauer writes:

"It seems clear to me that the traditional accounts of discoveries made by Thales or Pythagoras should be dismissed as completely unhistorical. Thales, for example, is credited with discovering that the area of a circle is divided by its diameter into two equal parts. But this account clearly

reflects the views of a much later period, when it already became clear that facts of this kind require proof before they could be used in subsequent theorems" ([23], p. 149).

"The myth of Saros is often used to "explain" the prediction of the solar eclipse of May 28, 584 BC, attributed to Thales. However, there isn't any cycle of visible solar eclipses for a particular place on Earth: all the modern cycles apply to the Earth as a whole. There wasn’t any Babylonian theory for predicting solar eclipses in 600 BC...

...Nor did the Babylonians develop any theory, that took into account the influence of the geographic latitude. We can safely say that the story about Thales' prediction of a solar eclipse isn't any more reliable than another similar story about Anaxagoras' prediction of a meteorite fall. Even from a purely historical point of view, the whole account seems very doubtful. Our earliest source, Herodotus [1, 74], reports that Thales correctly predicted to the Ionians "this disappearance of daylight" "for that year" in which it actually occurred. This whole formulation is so vague, that it

precludes the application of any scientific method. The farther we go from the time of Thales, the more generously ancient authors attribute to him various mathematical and astronomical discoveries, *and I do not see a single credible element in any of these accounts*, so popular in the history of science.

In this connection we may quote the conclusion from Cook's article... (we omit the bibliographical reference - *Auth.*):

"I can only conclude that our knowledge is insufficient to say with certainty whether the Ionians were the pioneers of Greek progress in the 8th and 7th centuries. On the basis of the currently available evidence, it is at least as likely that they were not."

Such a cautious point of view, unfortunately, is far from being generally accepted. I will cite one amusing nonsense, arising from the story of the eclipse predicted by Thales. In a scientific work (we omit the bibliographical reference again - *Auth.*) Wendel states (p. 20 and on) that

the pioneers (ger. Bahnbrecher) of Ionian science must have had a "staggeringly rich" library at their disposal and that Thales must have been its "spiritual founder". No need to say, that Thales' occupations in Egypt are treated very seriously too" ([23], p. 144).

It is astonishing how much Neugebauer's thoughts agree with Morozov's ideas! Only the hypnosis of certainty about the real existence of ancient science kept Neugebauer from coming to the self-evident conclusion.

Also, Neugebauer is overly cautious about attributing "amusing tall tales" to Wendel alone. In fact, all generally accepted ideas about the development of culture in antiquity, about the existence at that time of libraries, grammar schools, workshops where dozens of slaves copied books after the dictation (!), etc. – all of them arose as a result of an afterthought, intended to find a way to justify and rationalize the literary and orthographic level of "ancient" works along with the achievements of "ancient" science.

The consistent rationalization of uncritically perceived messages about the achievements of "ancient" science has also influenced ideas about its extraordinarily ancient origins, dating back to the knowledge of Egyptian and Babylonian priests. Here is how Neugebauer writes about it:

"The reader should be warned against using the work of "*Jerimias, Handbuch der altorientahschen Geisteskultur*". Using an incredible scholarly apparatus, the author developed a "Pan-Babylonian" doctrine which flourished in Germany between 1900 and 1914 and was completely abandoned after the World War I. The main thesis of this school was built on wild theories about the immense age of Babylonian astronomy... There wasn't any phenomenon in ancient cosmogony, religion, and literature that was not deduced from this hypothetical cosmic philosophy of the Babylonians. The condescending disregard for the obvious indications of the texts, the extensive use of secondary sources and outdated translations - combined with a biased chronology of Babylonian civilization - created a fantastic picture that had

(and still has) a great influence over the literature on Babylon" ([23], p. 140).

Rationally inexplicable level of "ancient" science and its fragmentary nature also gave rise to a lot of fantastic hypotheses: this science allegedly fed on the remnants of the achievements of some extremely ancient civilizations ("Atlantides"), nearly possessing the secret of nuclear energy and interplanetary travel, or it borrowed knowledge from "space aliens", and so on and so forth. We will not dwell on this, because now this topic is really fashionable, and the reader is undoubtedly familiar with these views.

Finally, as an example of the amusing misunderstandings that arise from blindly following "ancient" authorities, we will cite the story of the color of Sirius.

It has long been noticed that in Ptolemy's Almagest, Sirius is called red. This place has always puzzled astronomers since a change of a star's color over a period of time since the 2nd century is impossible even in

theory. A large number of witty but unconvincing explanations have been proposed. However, nobody doubted the color change itself, because Ptolemy's testimony was "supported" with the testimony of other authors. For example, Aratus writes about the red color of Sirius in his book "Phenomena and Prognostics", which has come down to us, according to traditional history, in the translation of Cicero himself. It is also written about by Horace, who compares Sirius even to Mars (!):

"redness is stronger in Sirius, less in Mars and completely absent in Jupiter" (Horace, "Satires", II, 39), and Seneca, who was writing straight out: "Red Sirius" .

From Morozov's point of view, the case here is quite clear: the author of "Almagest" made an elementary mistake, and all the listed works are apocrypha, whose authors, wishing to recreate colorite of the time and blindly following Ptolemy's authority, unwittingly gave out secondary nature of their information.

Just as it always happens, every "classical" primary source proven apocryphal also entails the proof of the apocryphal nature for a whole host of other, related works.

The exceptionalism of ancient society

The stamp of fantasticality and implausibility in the reports of the "classics" lays not only upon ancient science, but also upon the political, social, and economic structure of the "ancient world". In essence, this fantasticality is widely known, but under the influence of tradition it is always interpreted as "exceptionalism".

Exceptional is ancient Greece's blossoming of science and culture, not justified in any way by the development of productive forces and production relations, and - what is really strange - not having any effect on either technology or socio-political structures. Unwittingly, one has to appeal to the mysterious "spirit of Hellenism"!

Exceptional is the production relations ("antique slavery"), not observed anywhere else, but taken as an ideal

by colonizing slave traders and slave owners from the "era of initial accumulation of capital" (a Marxist term – tr.). Within the framework of these production relations, it is impossible to explain the traditional opinions on the technology of ancient society. Here is how Prof. Kovalyov, who wholeheartedly adheres to mainstream views, writes:

> "...it is much more interesting to unravel the *mystery of the technical revolution of ancient science, so mysterious in the conditions of slave production...* In these matters we are still wandering in the dark..." (196], p. 9).

The notion of the universal significance of ancient slavery, acknowledging the slave system as a necessary socio-economic formation on the way from the tribal society to the feudal one, comes into such a serious contradiction with the facts, that in recent years - despite the century-old tradition supported by the authority of the classics of Marxism-Leninism (turns out, they didn't insist on this view and even directly refuted it) - there was a directly opposite view, coinciding with ours, spreading wider and wider

among historians, and proposing the exclusivity of "ancient slavery" instead. The results of the relevant discussion are summarized in the book [155], just published in its second edition, where it is stated directly that "...apparently, for the majority of the nations of the Earth... the slaveowner formation... was, in fact, unknown" ([155], p. 13). All the most complex constructions thought up by the participants of the discussion in their attempts to combine the incompatible, discussed in detail in [155], turn out to be unnecessary, if we acknowledge that even "in a relatively narrow strip of the Near-Mediterranean" (expression from [155], p. 14), - which, as it is claimed in [155], was the only domain of the "classical slavery" - this slavery did not exist either.

Exceptional is the state system of the republican Rome, repeatedly praised and modeled by utopians. Its more or less long-term functioning requires such civic virtues, not found in ordinary life, that repeated attempts to "restore" it in the Middle Ages very quickly ended in complete failure.

This **exceptionalism** and fantasticality not just extend to global structures, but permeate every cell of ancient society (as traditional history presents it). The reader can set up an experiment: pick any detailed study on a certain matter of ancient life. With a very little chance to lose, one can bet that at the very first pages, he will find a report of some peculiarities exclusively characteristical to antiquity, the nature of which is such that one can only wonder at the seriousness with which they are discussed.

Not intending to deprive the reader of this pleasure, we will not discuss this topic further.

The Legend of the Dark Ages

The second, even more important, consequence of the apocryphalization of medieval science to antiquity is the idea of the stagnation of science in the Middle Ages and the creation of the popular myth of the "dark ages of the Medieval" as dark centuries of material and spiritual domination of feudalism, monastic fanaticism, unenlightened folk, and theologically-scholastic wisdom

(see, for example, [39], pp. 5-6). Traditional history regards the scholars of those times as creatively impotent commentators, mired in scholastic disputes and helplessly "repeating the backbones" of ancient science. The example of Purbach and Regiomontanus is very illustrative in this respect.

But recently, timidly at first, but then more and more confidently, many experts on the Middle Ages challenge this myth:

"...an important role in the evolution of the societies of the new Europe is usually attributed to the so-called "Renaissance" of the arts and sciences. This revival is usually depicted as a grandiose cultural upsurge, taking place in the societies of the new Europe due to their assimilation of the ideas of ancient education, which had allegedly destroyed the ascetic medieval worldview, which was shackling the human spirit with heavy chains of religion and preventing the development of its forces, which, allegedly only at that moment, came out of the gloomy prison for the first time, to

the light and air, and immediately blossomed into a lush flower of sciences and arts...

One hardly needs to add that *this whole picture is a typical example of purely idealistic, basically just logical, purely deductive construction, very far removed from the extremely complex... historical reality* it is seemingly trying to reconstruct...

The great interest in the classical world is more of a consequence of the very significant cultural success of Western European society rather than the cause of this success. The new, purely secular worldview that had developed in the educated circles of Europe by the beginning of the so-called New Age was a natural product of the entire previous very complex... development...

"Rejecting a cultural coup allegedly made... during the so-called "Renaissance" as a completely unscientific idea and instead considering this notion to be one of the many illusions of unreal historical thought, modern real historical scholarship is not at all inclined to give so-called

"humanism" the profound significance it is usually ascribed..." ([49], pp. 22-25).

These words of the most authoritative medievist demonstrate, that, despite the "hypnosis of antiquity", critically and independently thinking historians are quite aware of the inferiority of traditional ideas about the role and significance of the Middle Ages in the development of culture and science.

There weren't any "dark ages"! The torch of science was burning stronger and stronger in the hands of scientists carrying it from country to country and from century to century. Sometimes it stunned under the influence of political and economic shakeups in some countries, only temporarily and briefly, but remained alive and burning brightly in neighboring countries.

Just like in the New Times, the development of science in the Middle Ages was going in a constant and fierce struggle against the obscurantism of church ideology. The political conditions of the time forced scientists to cover

themselves with "ancient names". When the works ascribed to Aristotle (whose name, according to Morozov, translates very meaningfully as "the best conclusion") first began to spread in the 13th century, they were met with a bayonet by representatives of the official ideology:

> "...the church reacted very actively to the spread of Aristotle's doctrine, fighting scientists and scientifical centers with prohibitions and restrictions of an organizational nature. As early as 1209, the provincial synod of French bishops in Paris imposed a ban on the study of Aristotle's works, and in 1215 a second ban of similar nature appeared... The Roman curia... repeats the ban (in 1231 - *Auth.*)..." ([87], pp. 17-18).

And when administrative bans did not help, theologians personified by Thomas Aquinas perverted Aristotle's teaching, emasculated its materialistic content, and put it at the service of the church.

The traditional image of medieval scholarship was formed on the basis of works promoting lifeless "official"

ideology, while the living and searching forces hidden under pseudonyms were attributed to antiquity.

On the other hand, the opponents of the official ideology did not form a united front and used speculative rather than experimental methods. They did not research the world but guessed about it. This is one way to explain the wide variety of "ancient scientific schools", united only by their opposition to the worldview of the church.

Evolutionary Viewpoint

As long as we deny the existence of "ancient science," we also must inevitably reject the notion of the terrible catastrophe of the 5th century, when a barbarian invasion supposedly destroyed "ancient civilization" and mankind was forced to begin its cultural development anew.

In general, the historical concept of catastrophes, being very dramatic and exciting from the literary point of view, has no grounds in practice and is a vestige of a certain general point of view that existed in the 18th and 19th

centuries, not just in history but in other sciences too. The most striking example is the "catastrophe theory" of Georges Cuvier, the founder of comparative paleontology. He believed that our planet had repeatedly experienced colossal catastrophes killing most of the Earth's inhabitants. After each such upheaval, the animal world was reborn anew, but in a new composition (just like in traditional history, civilizations die and are reborn). This theory lasted till the middle 19th century when Darwin substantiated his "evolutionary teaching" – the theory of continuous evolution, continuous increase of the biological potential.

The idea that dramatic pictures of the death of entire civilizations should give way to a continuous evolutionary scheme (not denying, of course, revolutions that raise society to the next step of development) has been repeatedly raised in historical science.

"In Western European historiography, there is the Romanist school, which is very influential in scholarship and talent of its representatives. For the Romanist school, the political and social order of medieval Europe is only a

further development of phenomena and forms already developed by the Roman world, which was never crushed by the blows of the barbarians, because what was previously understood as the so-called barbarian invasion, a catastrophe that violently defeated the Roman state, is nothing more than a historical legend..." ([49], pp. 25-26).

Nevertheless, the fact that historical science as a whole has not yet abandoned "catastrophic" ideas and has not yet moved to evolutionary ideas - is a sad, but undeniable fact. The reason for this, undoubtedly, was the hypnosis of confidence about the existence of ancient culture and science, whose sudden vanishing from the face of the Earth is difficult to explain with something other than a catastrophe.

Of course, in bourgeois historiography, there were also other reasons. As Prof. Petrushevsky writes, stating the opinion of the famous bourgeois scientist Meyer:

"Meyer wages war against the "false" opinion that the historical development of the nations that lived around the Mediterranean Sea was going continuously on an

ascending line. He attributes the spread of this opinion to "popular philosophy, which eagerly pursues the theory of progress, and, not caring about facts, only composes fancy looking schemes..." " ([49], p. 31).

But we sure know which "popular philosophy" Meyer so easily and unhesitatingly dismissed...

Morozov repeatedly emphasizes the evolutionary character of his theory, and for us, this seems to be one of its most attractive aspects and one of its most profound theoretical confirmations.

Parallels

Apocryphal medieval writings must inevitably retain traces of their origin. Therefore, the traditional history based on them must have certain parallels between events of antiquity and the Middle Ages. And indeed, many scholars have been more or less surprised to find that the Middle Ages repeat the Antiquity in many respects. However, traditional history fairly successfully explains these

repetitions with, say, the unity of the general laws of development of human society or with other considerations.

Therefore, the repetitions support the claim that ancient literature is apocryphal, only insofar as this claim ***can explain these repetitions completely*** and without any further hypotheses or considerations.

We shall consider this question in detail in Chapters 16-18, but now, as one example, we shall only note that the political organization of the Roman Republic of the 9th and 10th centuries strikingly resembles the political organization of the "classical republic": there is a senate, two consuls are elected annually, and religious life is directed by the great pontifices (who received the name of "popes" later on in the 11th century).

However, little is known about this period of Rome's history. From our point of view, it is not surprising, since most of the information about it is apocryphed to antiquity.

Speaking in general, it is wrong to present the history of the Middle Ages as something complete and clear, even in its main features. On the contrary, it is full of dark places and gaping pits, lasting nearly centuries, from which almost no documents came down to us. What if the reason for this appears to be the apocryphalization of these documents to antiquity? Could the history of these dark years be reconstructed from the "ancient" sources?

The economic structures of the Middle Ages and Antiquity, when examined more closely, also turn out to be surprisingly similar. Here is what the same Professor Petrushevsky writes:

"Meyer finds it necessary to "point out in the most energetic manner that the history of the development of nations that lived by the Mediterranean *constitutes two parallel periods*, and that with the fall of the ancient world, the development begins anew, once again returning to those first stages which have long since been passed". Thus, the history of the nations that have lived and are living by

the shores of the Mediterranean, really is two parallel periods, and the nations of the new Europe underwent the same economic evolution as the nations of the ancient world" ([49], p. 32).

The far from trivial, and a priori not obvious conclusion about the repetition of the economic history of the Mediterranean did not cause much surprise and protest from traditional historians, but, put in line with other parallelisms, it acquires special significance.

Chapter Summary

1. The main theoretical conclusion of this chapter appears to be a rebuttal of the legend of the medieval "dark ages" and affirmation of the evolutionary viewpoint, which rejects catastrophes but, of course, not revolutions (see § 5).

Due to the lack of space and time, we have only briefly outlined the main ideas. All of them require in-depth elaboration and further development. But this is beyond the scope of this book.

2. The final text of the Almagest was proven to belong to the 15th-16th centuries; we also outlined the basic shape of the mechanism behind other "ancient" scientific works, that emerged in the Middle Ages (see §2 and §4).

Thus, no matter from which angle you approach, the thesis about the apocryphal nature of "ancient" literature (and science) finds the most diverse confirmation. In any case, with regard to a number of the most basic works, it can be considered proven with all certainty that astronomy can provide.

Not only monuments of writing but also archaeological finds (monuments of material culture) supposedly remained from ancient times. Let us see how clearly they speak about the past.